Ontario

Production Recommendations for GINSENG

Publication [illegible]0

MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Each year the appropriate sub-committee of the Ontario Pest Management Research and Services Committee reviews the pesticides listed in this publication. To the best knowledge of the sub-committee, all of these pesticides were:

- federally registered
- reviewed by the Ontario Pesticides Advisory Committee (OPAC) and
- classified by the Ministry of the Environment as of November 2000

Discard old editions of this publication.

The information in this publication is general information only. All pesticides must be used in accordance with the product label and Regulation 914 under Ontario's *Pesticides Act*.

Pay close attention to all instructions and warnings on the pesticide label.

By printing this publication, the Ministry of Agriculture, Food and Rural Affairs does not offer any warranty or guarantee, nor does it assume any liability for any crop loss, animal loss, health, safety or environmental hazard caused by the use of a pesticide mentioned in this publication.

Policy Statement

In this publication, most recommendations list several pesticides that can be used for each pest discussed. In general, the least hazardous materials and those growers have used satisfactorily for years are listed first. More toxic pesticides and/or newer ones with less practical grower experience follow. In some cases, the most effective pesticides are highly toxic.

This publication lists a number of brand names of pesticides. This is for the grower's convenience only. It is neither an endorsement of the product nor a suggestion that similar products are ineffective.

Weather and other factors influence the effectiveness of pesticides and the likelihood of crop injury by pest control chemicals. Consult the product label and other information regarding compatibility with other materials, the effect of environmental conditions, and so on for the specific product being considered. Wettable or soluble powders (WP, SP, WDG or DG) are less likely to cause plant injury than liquid concentrates (EC, SC and F).

Health Canada has established maximum residue limits (MRLs) for pesticides. However, growers should be aware that processors or retailers may demand more restrictive limits. Growers should seek advice of their intended market as to which restrictions or limitations apply. Growers are also encouraged to keep accurate and up to date records on pesticide use in each crop.

Federal Registration and Provincial Classification

The Ministry of the Environment administers Ontario's *Pesticides Act* and Regulation 914.

All pesticides sold and used in Ontario must be:

- registered under the federal *Pest Control Products Act*, and
- classified under the provincial *Pesticides Act* by being placed in one of six schedules of the Ontario regulation.

Federal Registration

The Pest Management Regulatory Agency (PMRA) of Health Canada grants registration following an evaluation of scientific data to ensure that the product has merit and value; and the human health and environmental risks associated with its proposed use are acceptable.

1. **Full Registration**
   Pesticide registrations are normally granted for a period of five years, subject to renewal.

2. **Temporary Registration**
   Temporary registration may be granted for a period not to exceed one year, where the registrant agrees to produce additional scientific or technical information, or the pesticide is used for emergency control of a serious pest outbreak.

For more information on the federal registration system contact the PMRA at 1-800-267-6315 or www.hc-sc.ca/pmra-arla.

Provincial Classification

There are six classification schedules in Regulation 914. Pesticide products are classified based on their toxicity, environmental or health hazard, persistence of the active ingredient or its metabolites, concentration, and usage. This system regulates the distribution, availability and use of pesticide products in Ontario. For up-to-date information on the regulatory status of these or other pesticides contact the:

Ontario Pesticides Advisory Committee (OPAC),
2300 Yonge St., Suite 1203, Toronto, ON, M4P 1E4
Telephone (416) 314-9230 Fax (416) 314-9237
www.opac.gov.on.ca

Farmer Certification

Regulation 914 of the *Pesticides Act* makes it mandatory for farmers to be certified through the Grower Pesticide Safety Course to buy and use Schedules 1, 2 or 5 pesticides on land they farm. There must be at least one Certified Grower for each farm operation.

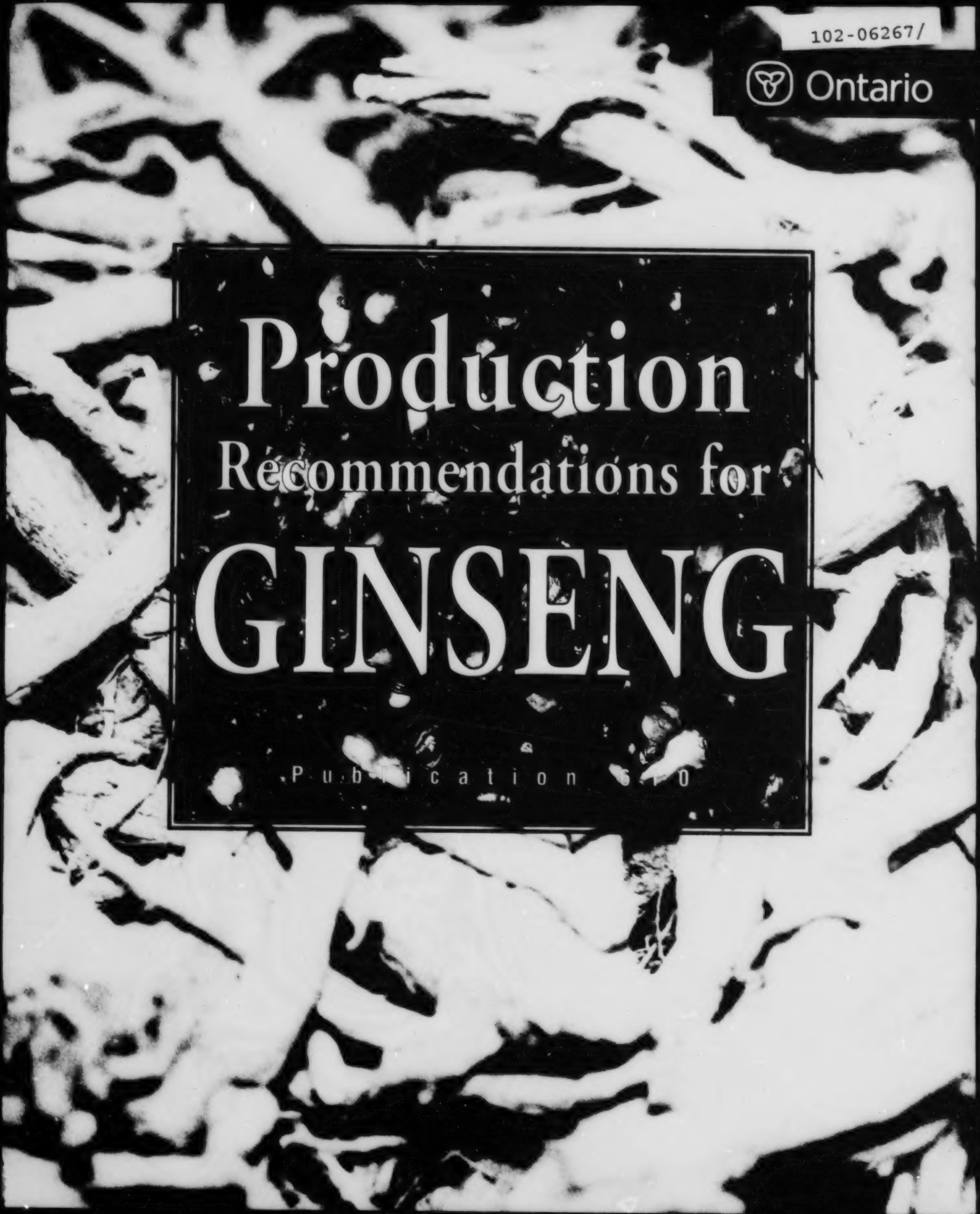
As of January 2000, all assistants must receive formal pesticide safety training, recognized by the Ministry of the Environment, before they can use Schedule 2 or 5 pesticides under the supervision of a Certified Grower. This applies to all assistants — including family members, farm employees and seasonal workers.

For more information check the Ontario Pesticide Education Program Web site at www.ridgetownc.uoguelph.ca/opep/ or call 1-800-652-8573 or (519) 674-1580

Cette publication est aussi disponible en français.

102-06267/

Ontario



Production Recommendations for GINSENG

Publication 610

MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Looking for pest control recommendations for ginseng in Ontario?

Phone the OMAFRA Ginseng Agriphone Hotline.
It's updated every Thursday from April through September and it's TOLL-FREE!

For a recorded voice message, call 1-888-290-4441.

Or call 1-888-466-2372 to receive the message by fax or e-mail.

Or check the ginseng Agriphone on the OMAFRA Web site at
http://www.gov.on.ca/omafra/english/crops/pestupd/index.html#ginseng

Current pests and diseases in ginseng are discussed at
http://www.gov.on.ca/omafra/english/crops/whatshot/whatshot.htm#ginseng

Looking for ginseng information on the Internet?
Check the ginseng Web site at
http://www.gov.on.ca/omafra/english/crops/hort/ginseng.html

It's one-stop shopping for factsheets, articles and photos regarding production, handling and marketing of ginseng in Ontario.

Need technical and business information?

Contact the Agricultural Information Centre at 1-877-424-1300
or ag.info@omafra.gov.on.ca.

Information in this book was contributed by:
OMAFRA Crop Technology
Agriculture and AgriFood Canada
University of Guelph

Life cycle and plant diagrams by Tiffany Wybouw.

Contents

1. Precautions With All Pesticides

- General Precautions 1
- Preventing Contamination of Farm Water Supplies 1
- If An Accident Occurs 2
- Relative Toxicity to Applicator 3
  - Definitions 3
    - High Acute Toxicity 3
    - Moderate Acute Toxicity 3
    - Low Acute Toxicity 3
    - Chronic Toxicity 3
  - Entering Treated Areas 3
  - Blood Tests for Those Applying Pesticides 4
- Protective Outdoor Clothing 4
  - Why Use Personal Protection? 4
  - Risk of Each Stage 4
  - Reducing Exposure 4
    - Protective Clothing 4
    - Respirators 4
  - Washing Protective Clothing 5
    - Fabric Clothing 5
    - Rubber, Vinyl or Plastic Boots and Gloves 5
    - Chemical-Resistant Clothing, Goggles and Face Mask 5
    - Respirators 5
    - Consult 5
- Protective Devices for Use in Enclosed Areas 5
  - Canister Gas Masks 5
  - Self-Contained Breathing Apparatus 5
  - Other Protective Clothing 5
  - Working Conditions 5
- Space Fumigants and Insecticide Smokes 5
  - Fumigants 6
- Storing Pesticides 7
  - Schedule 1, 2 and 5 pesticides 7
- Disposal of Pesticide Containers or Contaminated Material 7
  - Soluble Packaging Available 7
    - Handling 8
    - Mixing 8
    - Compatibility 8
- Sprayers 8
  - Ginseng Spray Technology 8
- Application by Airplane or Helicopter 8
- Pesticide Drift 9
- Residues on Crops to Be Harvested, Fed or Grazed 9
- Bee Poisoning 9
- Pesticide Concentration 10
- Pesticide Certification for Ontario Farmers 10
  - Training for Assistants Using Schedule 2 or 5 Pesticides 10

2. Soil Management and Fertilizer Use

- Soil Testing 11
  - Other Methods of Assessing Nutrient Needs 11
  - What Does the OMAFRA-Accredited Soil Testing Program Provide for the Farmer? 11
  - Soil Sampling 12
    - When to Sample 12
    - Information on Accredited Labs 12
- Plant Analysis 13
  - Sampling 13
  - Sample Preparation 13
- Micronutrient Tests 13
  - Contamination 13
  - Soil Sampling 13
- Fertilizer Recommendations 13
  - Soil Acidity and Liming 13
    - The Buffer pH 14
  - Limestone Quality 14
    - The Agricultural Index 14
    - Tillage Depth 15
    - Lowering Soil pH 15
  - Nitrogen 15
  - Phosphate and Potash 15
  - Magnesium 16
- Micronutrient Fertilizers 16
  - Preventing and Correcting Manganese Deficiency 17
  - Preventing and Correcting Zinc Deficiency 17
- Adjustments to Fertilizer Recommendations 17
  - Adjustment for Legumes Ploughed Down 17
  - Manure 18
    - Manure Analysis 18
  - Long-Term Value of Manure 18
  - Crop Requirements 19
  - Biosolids 19
  - Calibrating Spreaders 19
  - Environmental Concerns With Manure 20
- Fertilizer Materials 21
  - Soluble Salts in Farm Soils 21
  - Toxicity of Fertilizer Materials 22
    - Nitrogen Fertilizers 22
    - Phosphate Fertilizers 22
    - Potash Fertilizers 22
    - Fertilizers Containing Micronutrients 22
    - Foliar Fertilizers 22
- Managing Soil Organic Matter 23
- Cover Crops 23
  - Grasses 23
    - Ryegrass (Annual, Italian or Perennial) 23
  - Spring Cereals 23
    - Sorghum Sudan 23
    - Winter Rye 23
    - Winter Wheat 24
  - Legumes 24
    - Hairy Vetch 25
    - Red Clover 25
    - Sweet Clover 25
  - Non-Legume Broadleaves 25
    - Buckwheat 25
    - Oilseed Radish 26

3. Basic Requirements of Ginseng Production

- Introduction 27
- Site Selection 28
- Nutritional Requirements 28
- pH 28
- Organic Matter 28
- Soil Type 28
- Water Management 28

Grading the Garden 28
Topographical Assessment 28
Dealing With Excess Water 29
Dealing With Soil Compaction 29
Rusty Root 29
Initial Steps in Ginseng Production 29
Weed Management/Cover Cropping 29
Fumigation 29
Bed Formation and Seeding 29
Managing Soil Temperature and Moisture 30
Managing Shade Requirements 30

4. Flowering and Seed Set in Ginseng

Ginseng Flowers 31
Ginseng Flower Development 31
Pollination 31
Ginseng Seeds and Berries 32
Embryo Development 32
The Ginseng Embryo 32
Seed Size 33
Testing Ginseng Seed 33
Planting Ginseng Seeds 33
Ginseng Emergence 33
Seeding Rate 33
Plant Stand 33
Deflowering Ginseng 33
Effects of Deflowering 33
Flower Bud Development 34
Root Growth 34
Deciding to Deflower 34
Assumptions Before Using the Matrix 34
Interpreting the Deflowering Matrix 34

5. Harvesting and Handling Ginseng Seeds and Roots

Harvesting and Handling Ginseng Seeds 35
Harvesting Ginseng Berries 35
Depulping Ginseng Berries 35
Handling Green Seed 35
Surface Sterilizing Seeds 35
Stratifying Ginseng Seeds 35
Below-Ground Stratification 35
Above-Ground Stratification 36
Harvesting Ginseng Roots 36
Ginsenosides and Polysaccharides 36
Root Age 36
Root Size and Shape 36
Harvest Date and Dry Matter Content 37
Harvest Date and Starch Content 37
Harvest Date and Root Colour 37
Harvest Date and Ginsenosides 37
Conditioning Ginseng Roots 37
Advantages of Root Conditioning 37
Root Conditioning Temperature 37
Root Conditioning Temperature and Dry Matter Content 37
Root Conditioning Temperature and Starch 37
Root Conditioning Temperature and Ginsenosides 37
Root Conditioning Temperature and Colour 37
Length of Root Conditioning 37
Drying Ginseng Roots 38
Drying Temperature and Ginsenosides 38
Drying Temperature and Starch 38
Drying Temperature and Root Colour 38

6. Diseases and Pests

Nematodes 39
Insects 39
Cutworms 39
Cultural Control 40
Chemical Control 40
Four-Lined Plant Bug – *Poecilocapsus lineatus* (Fabricus) 40
Cultural Control 40
Chemical Control 41
Pit Scale – *Asterolecanium arabidis* (Signoret) 41
Leaf Roller – *Archips purpurana* (Clem.), *Argyrotaenia velutinana* (Wlk.) (red banded leaf roller) 41
Mealybugs – *Acanthococcus dubius* 41
Stem Borers 42
Weeds 42
Preplant Weed Control 42
Introduced Weeds 42
General Pests 42
Slugs 42
Rodents 43
Disease Control 43
Sprayer Technology 43
Fungicide Resistance 44
Causes 44
Prevention 44
Timing 44
Rate 45
Coverage 45
Rotation 45
Seeding Rates 45
Water Management 45
Fertility Practices 45
Air Circulation 45
Disinfecting Equipment 45
Diseases of Seed Heads and Flower Heads 45
Alternaria panax 46
Botrytis cinerea 46
Powdery Mildew 46
Diseases of Ginseng Seeds 46
Post-Harvest Diseases and Disorders of Ginseng 46
Red Root (Varicose Disorder) 46
Mouldy Root 47
Rhizopus Rot 47
Geotrichum Mould 47
Disease Profiles 47
Pythium Damping Off of Ginseng 47
The Fungus and Symptoms 47
Factors Promoting Disease 48
Disease Management Practices 49
Cultural Control 49
Chemical Control 49
Rhizoctonia Diseases of Ginseng 49
The Fungus and Symptoms 49
Factors Promoting Disease 50
Disease Management Practices 50
Cultural Control 50
Chemical Control 51
Phytophthora Root Rot and Blight of Ginseng 51
The Fungus and Symptoms 51
Factors Promoting Disease 51

Disease Management Practices 52
Cultural Control 52
Chemical Control 53
Alternaria Diseases of Ginseng 53
The Fungus and Symptoms 53
Factors Promoting Disease 55
Disease Management Practices 55
Cultural Control 55
Chemical Control 55
Botrytis Blight of Ginseng 55
The Fungus and Symptoms 55
Factors Promoting Disease 57
Disease Management Practices 57
Cultural Control 57
Chemical Control 57
Cylindrocarpon Diseases of Ginseng 57
The Fungus and Symptoms 57
Factors Promoting Disease 58
Disease Management Practices 58
Cultural Control 58
Chemical Control 58
Rusty Root 58
Abiotic Disorders of Ginseng 59
Heat Stress 59
Air Pollution 59
Boron Toxicity 60
Herbicide Drift 60
Herbicide Residue in the Spray Tank 60
Foliar Fertilizers Mixed With Fungicides 60

7. Pest Control Recommendations

TABLE 7–1. Preplant Fumigation in Ginseng 61
TABLE 7–2. Insect Control in Ginseng 61
TABLE 7–3. Weed Control in Ginseng 62
TABLE 7–4. Rodent Control 62
TABLE 7–5. Disease Control Recommendations for Ginseng in Ontario 63
TABLE 7–6. Formaldehyde Seed Soak 64

8. Appendices

APPENDIX A. Ginseng Export Regulations 65
APPENDIX B. Diagnostic Service 66
APPENDIX C. Phytosanitary Certificates 67
APPENDIX D. Other Contacts 68
APPENDIX E. Accredited Soil Testing Labs in Ontario 69
APPENDIX F. Ontario Ministry of the Environment Pesticide Control Offices 70
APPENDIX G. The Metric System 71

9. Colour Plates 73

* * *

Tables

1. Precautions With All Pesticides

TABLE 1–1. Toxicity of Products Listed in Publication 610 3
TABLE 1–2. Safety Supply Companies in Ontario Providing Protective Clothing and Equipment 6
TABLE 1–3. Relative Toxicity of Insecticides to Honeybees ..10

2. Soil Management and Fertilizer Use

TABLE 2–1. OMAFRA-Accredited Soil Tests 11
TABLE 2–2. Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH 14
TABLE 2–3. Example Calculation of the Fineness Rating of a Limestone 14
TABLE 2–4. Phosphorus Requirements for Ginseng on Mineral Soils 15
TABLE 2–5. Potassium Requirements for Ginseng on Mineral Soils 16
TABLE 2–6. Manganese Soil Test Interpretation 16
TABLE 2–7. Zinc Soil Test Interpretation 17
TABLE 2–8. Adjustment of Nitrogen Requirement Where Crops Containing Legumes Are Ploughed Down ..17
TABLE 2–9. Average Amounts of Available Nutrients for Different Types of Manure 18
TABLE 2–10. Approximate Ammonium-Nitrogen Levels Available by Livestock Type 19
TABLE 2–11. Estimated Percentage of Ammonium-Nitrogen Lost Due to Weather and Soil Conditions 19
TABLE 2–12. Calibrating Manure Spreaders 20
TABLE 2–13. Densities of Different Types of Manure 20
TABLE 2–14. Determining Minimum Separation Distance From Watercourses 20
TABLE 2–15. Fertilizer Materials — Primary Nutrients 21
TABLE 2–16. Fertilizer Materials — Secondary and Micronutrients 21
TABLE 2–17. Soil Conductivity Reading Interpretation 22
TABLE 2–18. Characteristics of Cover Crops Grown in Ontario 24

4. Flowering and Seed Set in Ginseng

TABLE 4–1. Seeding Rate and Equivalent 100% Plant Stand in the Seedling Year 33
TABLE 4–2. Deflowering Decision Matrix 34

6. Diseases and Pests

TABLE 6–1. Boom Sprayer Set-Up 43
TABLE 6–2. Disinfecting Equipment 45
TABLE 6–3. Quick Disease Reference for Ginseng 59

7. Pest Control Recommendations

TABLE 7–1. Preplant Fumigation in Ginseng 61
TABLE 7–2. Insect Control in Ginseng 61
TABLE 7–3. Weed Control in Ginseng 62
TABLE 7–4. Rodent Control 62
TABLE 7–5. Disease Control Recommendations for Ginseng in Ontario 63
TABLE 7–6. Formaldehyde Seed Soak 64

Figures

3. Basic Requirements of Ginseng Production

FIGURE 3–1. North American Ginseng, *Panax quinquefolius:* Roots, Leaves, Seed Head, Flower, Seeds.......27

4. Flowering and Seed Set in Ginseng

FIGURE 4–1. Ginseng Seed Head With Concurrent Flower Buds, Flowers and Berries................................31
FIGURE 4–2. Germination of Ginseng Seed...........................32

6. Diseases and Pests

FIGURE 6–1. Life Cycle of *Pythium* on Ginseng 48
FIGURE 6–2. Life Cycle of *Rhizoctonia* on Ginseng................50
FIGURE 6–3. Life Cycle of *Phytophthora* on Ginseng 52
FIGURE 6–4. Life Cycle of *Alternaria* on Ginseng 54
FIGURE 6–5. Life Cycle of *Botrytis* on Ginseng 56

Plates

PLATE 1. Grading gardens for water removal 73
PLATE 2. Missing plants in waterways 73
PLATE 3. Standing water in trenches 73
PLATE 4. Forming ginseng beds 73
PLATE 5. Bed-forming equipment 73
PLATE 6. Seeding ginseng 73
PLATE 7. Applying straw to ginseng beds 74
PLATE 8. Low wood shade 74
PLATE 9. Low cloth shade 74
PLATE 10. Ginseng embryo 74
PLATE 11. *Rhizoctonia*-infected seed 74
PLATE 12. *Pythium*-infected seed 74
PLATE 13. *Fusarium*- and *Cylindrocarpon*-infected seed 75
PLATE 14. Sporodochia on the seed coat 75
PLATE 15. Bacterial seed decay 75
PLATE 16. Harvesting ginseng berries 75
PLATE 17. Depulping ginseng berries 75
PLATE 18. Green seed 75
PLATE 19. A ginseng seedbox 76
PLATE 20. Stratified ginseng seed 76
PLATE 21. Checking the seedbox 76
PLATE 22. Harvesting ginseng roots 76
PLATE 23. Conditioning ginseng roots 76
PLATE 24. Tumble root washer 76
PLATE 25. Unwashed ginseng roots 77
PLATE 26. Washed ginseng roots 77
PLATE 27. Drying trays 77
PLATE 28. Drying kiln 77
PLATE 29. Dried ginseng roots 77
PLATE 30. Dried ginseng roots — interior colour 77
PLATE 31. High temperature damage in the dryer 78
PLATE 32. Red root/varicose disorder 78
PLATE 33. Close-up of red root 78
PLATE 34. Cross-section of red root 78
PLATE 35. Dryer mould — *Rhizopus* 78
PLATE 36. *Rhizopus* on dried roots 78
PLATE 37. Dryer mould — *Geotrichum* 79
PLATE 38. Root-knot nematode damage 79
PLATE 39. Cutworm damage to seedlings 79
PLATE 40. Four-lined plant bug on mint 79
PLATE 41. Four-lined plant bug 79
PLATE 42. Four-lined plant bug damage on seedlings 79
PLATE 43. Four-lined plant bug damage on older plants 80
PLATE 44. Mint as a trap crop 80
PLATE 45. Ginseng pit scale 80
PLATE 46. Pit scale on ginseng 80
PLATE 47. Leaf roller damage in ginseng 80
PLATE 48. Leaf roller larva in ginseng 80
PLATE 49. Ginseng mealybug 81
PLATE 50. Mealybug egg case 81
PLATE 51. Mealybug damage on ginseng 81
PLATE 52. Volunteer cereal in ginseng 81
PLATE 53. Slug damage on ginseng leaves 81
PLATE 54. Pythium root rot 81
PLATE 55. Missing plants due to *Rhizoctonia* 82
PLATE 56. *Rhizoctonia* infections on 2-year-old ginseng roots 82
PLATE 57. *Rhizoctonia* infection on older roots 82
PLATE 58. *Rhizoctonia* on seedling roots 83
PLATE 59. *Rhizoctonia* winter injury on 2-year-old ginseng roots 82
PLATE 60. Rhizoctonia damping-off 82
PLATE 61. Phytophthora root rot 83
PLATE 62. Cylindrocarpon and phytophthora root rots 83
PLATE 63. Above-ground symptoms of phytophthora root rot 83
PLATE 64. Symptoms of advanced phytophthora root rot 83
PLATE 65. Phytophthora leaf blight 83
PLATE 66. *Phytophthora* in a wet area 83
PLATE 67. *Alternaria* stem lesion 84
PLATE 68. *Alternaria* leaf lesions 84
PLATE 69. Ginseng defoliated by *Alternaria* 84
PLATE 70. Alternaria head blight 84
PLATE 71. *Botrytis* sclerotia 84
PLATE 72. Botrytis head blight 84
PLATE 73. Advanced botrytis head blight 85
PLATE 74. Plant-to-plant spread of *Botrytis* 85
PLATE 75. Botrytis leaf blight 85
PLATE 76. Botrytis leaf blight 85
PLATE 77. *Botrytis* on ginseng roots 85
PLATE 78. *Cylindrocarpon* root decay 85
PLATE 79. *Cylindrocarpon* on seedlings 86
PLATE 80. *Cylindrocarpon* on 2-year-old roots 86
PLATE 81. Above-ground symptoms of root decay 86
PLATE 82. Above-ground symptoms of advanced *Cylindrocarpon* root decay 86
PLATE 83. Disappearing root rot 86
PLATE 84. Early root symptoms of *Cylindrocarpon* root infection 86
PLATE 85. Mid-root *Cylindrocarpon* infection 87
PLATE 86. Symptoms of rusty root 87
PLATE 87. Rusty root lesions on older root 87
PLATE 88. Superficial rusty root lesion 87
PLATE 89. *Rhizoctonia* on older roots 87
PLATE 90. Rusty root on the crown 87
PLATE 91. Papery leaf spot 88
PLATE 92. Air pollution damage 88
PLATE 93. Boron toxicity 88
PLATE 94. Herbicide drift 88
PLATE 95. Herbicide leaf burn 88
PLATE 96. Fertilizer burn on leaves 88

1. Precautions With All Pesticides

General Precautions

- Before beginning work with pesticides, make sure someone knows where you are working and what pesticides you are handling. Post the telephone number for your Poison Information Centre near your telephone.
- When handling pesticides, have clean water nearby at all times and keep an extra set of coveralls close in case the material spills on you.
- Before opening pesticide containers, always read the label and follow all precautions and directions.
- Keep a record of the common names of all the pesticides you handle, especially those listed as hazardous in this publication. Be sure other members of your family know where this list is in case of an accident.
- Never smoke, chew tobacco or eat while handling or applying pesticides. Never carry tobacco or food in your clothes while spraying.
- Change your clothes and wash before you eat.
- When handling and mixing pesticide concentrates, rinsing empty containers or repairing leaks, wear a full set of protective clothing. This includes a waterproof cap, coveralls, chemical resistant gloves and boots, and safety goggles.
- Wear a respirator if using highly or extremely toxic pesticides or very dusty formulations. Never wear a dust mask. These types of masks do not protect you from pesticides. You must wear a respirator if handling volatiles or gases. If these gases are highly dangerous or you are handling them in an enclosed space, you may need a self-contained breathing apparatus. Make sure you follow the instructions on the product label.
- Use an anti-backflow device to prevent back-siphoning when drawing water from wells, ponds, streams or other sources.
- Mix pesticides at least 50 m from wells, ponds or streams. Triple or pressure rinse the empty container and add the rinse water to the tank. Only mix enough solution to do the spray job. When loading and mixing are finished, wash gloves and boots with soap and clean water before removing them.

Always read the product label and follow the safety instructions.

- When applying pesticides, use a tractor cab with an activated charcoal filter for protection against respiratory exposure. Do not contaminate the cab area by wearing pesticide-contaminated protective clothing and equipment.
- Wear the appropriate respirator, chemical-resistant gloves, boots, coveralls and waterproof head covering when tending to the sprayer.
- When using airblast and mist blowers or tractors without cabs, wear the appropriate respirator, waterproof suit and head covering, and chemical resistant gloves and boots. Once spray application is completed, clean both those areas of the tractor contacted by spray and your protective equipment. Do not operate the tractor without wearing protective clothing and equipment, unless it has been decontaminated.
- When applying fumigants in the field, have a respirator on hand in case you need to deal with equipment problems or in case inadequate sealing in the soil allows the fumigant to escape.
- When the spray operation is completed, wash hands with soap and water before entering pesticide-free areas. Bathe or shower to remove pesticide deposits on your skin. Do not handle anything in your home before you bathe.

Preventing Contamination of Farm Water Supplies

Pesticides can contaminate well, pond and surface water. It is an offence to contaminate surface waters with pesticides. Taking the following steps will help prevent contamination.

- Keep pesticide concentrates above any flood plain in locked storage.
- After emptying containers, triple or pressure rinse, crush and dispose of the containers according to product label instructions.

- Return empty plastic or metal containers to a dealer who participates in the container-recycling program. Empty bags may be burned or disposed at a landfill site.
- Mix pesticide and load the sprayer at least 50 m away from any water supply.
- Use buffer zones and berms to avoid contaminating surface water, wells, ponds and/or streams.
- Do not use drinking water sources to fill spray equipment. If you fill your tank from a well, lake, river or other surface water source, you must use an anti-backflow device.
- Do not spray within 10 m of shallow wells or 5–10 m of other water supplies in ideal weather and farther away if there is any air movement. Stop spraying when wind velocity reaches 10 km/hr.

If An Accident Occurs

1. Always protect yourself from injury first.

- Don't become another victim. Always put on protective clothing and equipment before you enter a contaminated area or handle a contaminated victim.
- If clothing becomes wet with a pesticide, remove it immediately, wash/bathe yourself and put on fresh clothes.

2. Check to see if the victim is breathing.

If the victim is not breathing:

- Straighten the victim's airway and check for breath.
- If the victim does not begin to breathe, administer artificial respiration until the victim begins to breathe on his or her own.
- Do not contaminate yourself, especially if the victim has pesticide or vomit around the face or mouth. Use a face shield airway with a one-way valve. Do not breathe the exhaled air from the victim.
- Perform CPR if the victim's pulse disappears. You should only perform CPR if you are trained to do so.

If the victim is breathing, but unconscious:

- Place the victim in the recovery position (on the side with the head turned slightly to one side). If the victim vomits, try to keep the airway clear.

3. Stop the exposure to the pesticide.

Move the victim away from the contaminated area. Remove all contaminated clothing. Use soap and water to wash any skin exposed to the pesticide.

4. Check the Four Basic Facts.

1. Identify the pesticide. Look for the label, container or leftover pesticide.
2. Quantity. How much product was the victim exposed to?
3. Route of entry. How did the pesticide enter the body? Did it enter through the mouth, skin/eyes or lungs?
4. Time period. How much time has passed since the victim was exposed to the pesticide, and how long was the exposure? Were the symptoms immediate or did the poisoning occur as a result of using the pesticide over a longer period of time?

Don't waste time. If you can't answer these questions quickly, be ready to tell emergency personnel whatever you can.

5. Call an ambulance or the Poison Information Centre.

6. Start the First Aid treatment appropriate for the route of entry.

7. Make sure the patient gets medical attention. First aid is not a substitute for professional medical help.

If your clothes get wet with a pesticide, remove them — immediately!

8. If symptoms of illness occur during or shortly after handling a pesticide, go to a hospital.

Take your list of common-name chemicals with you. (See *Emergency Procedures for Pesticide Poisoning* on the inside back cover.)

If a pesticide spill causes, or is likely to cause, an adverse effect, you must notify the Ministry of Environment, Spills Action Centre at 1-800-268-6060 (24 hours/day, 7 days/week) and the municipality.

9. Clean up any pesticide spills immediately.

In the case of minor spills, use dry soil or other absorbent material such as kitty litter to remove excess liquid. Sweep up powders and granulars. Spread contaminated soil and sweepings over a large area of bare soil to facilitate rapid degradation. Make sure you are adequately protected when cleaning up a spill. For information on preventing spills, see the OMAFRA

Factsheet, *Ways to Avoid Pesticide Spills*, Order No. 96-025. (See inside front cover for information on how to obtain factsheets.)

10. Clean up any contaminated wells.
Follow the clean-up instructions in the OMAFRA Factsheet, *Pesticide Contamination of Farm Water Supplies*, Order No 00-099. (See inside front cover for information on how to obtain factsheets.)

Emergency Procedures for Pesticide Poisoning and First-Aid Information

(See inside back cover.)

Relative Toxicity to Applicator

Definitions

Lethal Dose 50% (LD_{50}) The dose that, when administered, will kill 50% of the test animals within a stated period.

Acute Toxicity Immediate adverse effects from a single or short period of exposure to a substance that enters the body by the oral, dermal or inhalation route.

Chronic Toxicity Adverse effects resulting from repeated exposure to a substance over an extended period.

High Acute Toxicity

These pesticides are extremely dangerous if handled carelessly. The acute oral LD_{50} is less than 50 mg/kg of body weight, and the acute dermal LD_{50} is less than 200 mg/kg body weight.

- These pesticides can be fatal in amounts of less than 0.1–3.0 mL (1 drop to half a teaspoon).
- These pesticides are labelled with the skull and crossbones in a stop sign.
- You must use a respirator and eye protection along with all other protective clothing when working with the products listed in Table 1–1, *Toxicity of Products Listed in Publication 610*, right.

Moderate Acute Toxicity

These pesticides are dangerous if handled carelessly. The acute oral LD_{50} is 50–500mg/kg of body weight, and the acute dermal LD_{50} is 200–2,000 mg/kg body weight.

TABLE 1–1.
Toxicity of Products Listed in Publication 610

Product Name	Chemical Name	Oral LD_{50}	Dermal LD_{50}
High Acute Toxicity			
rodent bait rodent pellets	zinc phosphide	40–46	
Moderate Acute Toxicity			
Basamid	dazomet	500	
Busan 1020	metam-sodium	97	800
Telone C17R Telone II B	dichloropropene chloropicrin	250–500	
Vapam	metam-sodium	97	800
Vorlex Plus Vorlex Plus CP	methylisothiocyanate chloropicrin 1,3-dichloropropene	300	2,780

- These pesticides can be fatal in amounts of 3–30 mL (half a teaspoon to 2 tablespoons).
- These pesticides are labelled with the skull and crossbones on a stop sign.
- Wear a respirator when working with the concentrates listed in Table 1–1, above.

Low Acute Toxicity

These pesticides are not fatal unless deliberately ingested in amounts of over 30 mL (1 oz). The acute oral LD_{50} is greater than 500 mg/kg body weight, and the acute dermal LD_{50} is greater than 2,000 mg/kg body weight. Pesticides listed in this publication and not in Table 1–1, above, have low acute toxicities.

- Handle these pesticides with caution.
- You must wear protective clothing.
- Wear safety goggles, and if using these products in a confined space, use a respirator.

Chronic Toxicity

It is not possible to assess chronic toxicity of a pesticide in the same way an LD_{50} is used to determine acute toxicity. Instead, a number of tests performed on animals help predict whether a pesticide may cause long-term effects. Animals are examined for a variety of toxic effects such as the production of tumours or abnormalities. Use protective clothing and equipment to help reduce exposure and the risk of chronic effects.

Entering Treated Areas

Workers may be poisoned if they enter fields without wearing protective equipment too soon after pesticides have been applied. Such poisoning can result from handling treated plants or from inhaling pesticide vapours. Check all labels carefully for any warnings or cautions that apply to re-entry after treatment.

Blood Tests for Those Applying Pesticides

Organophosphorus and carbamate pesticides can affect a person's serum and red blood cholinesterase levels. If cholinesterase activity falls below a critical level, poisoning can result. Symptoms include fatigue, dizziness, nausea, trembling, blurred vision and difficulty breathing.

Protective Outdoor Clothing

Why Use Personal Protection?

Pesticide formulations vary in toxicity from slightly to extremely poisonous. Exposure occurs once the pesticide is removed from the container. The toxicity of the pesticide and exposure to the user create a hazard. Both can be reduced — toxicity by dilution and exposure by wearing protective clothing. Wearing protective clothing reduces the hazards of spraying and thus the risk of poisoning.

Risk of Each Stage

Handling and mixing concentrate	very high risk
Rinsing empty containers	high risk
Applying outdoors	low to high risk
Applying indoors	medium to very high risk
Cleaning up, rinsing equipment	medium to high risk
Entering treated area within 48 hours	low to very high risk

Reducing Exposure

Exposure to pesticides can be through skin, eyes, mouth or nose. In most spray operations, about 80%–85% of the exposure occurs during mixing and loading of the product concentrate. Field application usually accounts for 15%–20% of the exposure. Skin exposure is usually 90%–100% of the total exposure. Around 70% of this is by way of the hands and forearms, and 30% involves the rest of the body. Inhalation (nose and mouth) exposure is normally 0.1% but rises to 5%–10% with mist blowers and air blast sprayers, and where product formulations are fine powders.

Protective Clothing

- To reduce skin (dermal) exposure, wear impervious gloves. Always refer to the product label. Unless the label states otherwise, use neoprene or nitrile gloves. Always wear waterproof boots, along with coveralls, apron or spray suits and a waterproof cap.
- Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. It's easier for the pesticides to penetrate polyester than cotton. Thoroughly launder reusable coveralls in laundry loads separate from normal clothing.
- Use spray suits in highly hazardous conditions such as with mist blowers and air blast machines.
- Protect your eyes with safety goggles when working with any pesticide concentrate.

For a normal spray operation, follow these guidelines, preferably twice a day, but at minimum at the end of the work day:

- **Rinse clothing outdoors.**
- **Soak and wash protective clothing separately from other clothes.**
- **Soak protective clothing with detergent in a container such as a large bucket or tub or use the pre-wash cycle of an automatic washer, with detergent. Solvent-based, pre-wash products work on EC pesticide formulations.**
- **Wash only a few garments at a time.**
- **Use heavy-duty liquid detergents.**
- **Use hot water, the highest water level and a regular, hot super-wash cycle.**
- **Do two complete wash cycles, each with a double rinse.**
- **After washing, run another wash cycle with detergent and no clothing to decontaminate the washing machine.**
- **Hang the clothes to dry, outside if possible, to avoid a potential build-up of pesticide residue in the dryer.**

Respirators

- Use respirators when handling pesticides with labels that call for respiratory protection and carry the warning stop sign with skull and crossbones.
- Use respirators when spraying any pesticide rated as high toxicity or when applying any liquefied gas.
- Respirators are available as air purifiers or self-contained units and come in a wide range of shapes and sizes. Consult the label and your nearest safety supply company for advice.
- Ensure that you purchase NIOSH (National Institute for Occupational Safety and Health) -approved respirators, pesticide cartridges and prefilters.

Washing Protective Clothing

- Clean your protective clothing and equipment thoroughly.
- Never let children or pets come in contact with contaminated clothing or equipment.
- Launder clothing promptly. Wash and store all personal protection items in a clean safe place.
- Rinse spray equipment and store it away to prevent children playing with it.

Fabric Clothing

- If fabric is saturated with the concentrate of a highly toxic pesticide, throw it out.
- Wear nitrile or neoprene gloves when handling severely contaminated clothing.
- Remove the clothing carefully and immediately put it in a plastic bag and dispose of it in a safe manner.

Rubber, Vinyl or Plastic Boots and Gloves

- To avoid getting pesticide on your hands, wash the outside of your boots and gloves with detergent and water before taking them off.
- After removing boots and gloves, wash them inside and out with detergent and water, rinse thoroughly and dry in a well-ventilated area.

Chemical-Resistant Clothing, Goggles and Face Mask

- Wash plastic or rubber clothing and equipment with detergent and water, rinse thoroughly and dry in a well-ventilated area.

Respirators

- Discard cartridges, canisters and filter pads when breathing becomes difficult, when you notice a pesticide odour or at the interval set by the manufacturer.
- Make a note of the date the cartridge is first used.
- Remove cartridges and filter pads from the face piece and store in clean, sealed plastic bags.
- Wash the face piece in detergent and water, rinse thoroughly and dry in a well-ventilated area.
- Never use alcohol or other solvents for cleaning, as they will damage the rubber and plastic.

Consult

Consult the safety supply house of your choice for help in selecting your protective clothing. (See Table 1–2, *Safety Supply Companies in Ontario Providing Protective Clothing and Equipment*, on page 6.)

Protective Devices for Use in Enclosed Areas

Canister Gas Masks

- Canister gas masks protect against certain harmful gases, vapours and particulate matter. They are generally suitable for ventilated areas not subject to rapid change.
- Do not use in confined spaces where oxygen deficiency and high gas concentrations may occur.

Self-Contained Breathing Apparatus

- Air purifying apparatuses do not work in confined spaces where gas concentrations are unusually high. The lack of oxygen can prove fatal. Under these conditions, use an air supply provided by a self-contained breathing apparatus (e.g., Scott Air Pack).
- Using substances that produce hydrogen cyanide, methyl bromide, chloropicrin or phosphine can produce high gas concentrations and oxygen deficiency as can smoke generators, foggers using highly toxic pesticides and some volatile sprays.

Other Protective Clothing

Wear other protective clothing in keeping with requirements listed on the pesticide label.

Working Conditions

- Use canister gas masks when the surrounding air contains low concentrations of toxic gases, vapours or particulate matter derived from soil-drench, granular, dust or foliar spray applications. Pesticides applied in this manner usually have moderate to low toxicity.
- You must use a self-contained breathing apparatus (e.g., Scott Air Pack) when applying highly toxic pesticides. These can produce high concentrations of toxic gases, vapours or particulate matter, and a lack of oxygen, especially in an enclosed space (e.g., fumigating grain). Contact your safety supply company for their recommendation.

Space Fumigants and Insecticide Smokes

Learn about the health hazards and toxic properties of the pesticide you're using. Consult the product label, Material Safety Data Sheets (MSDS) or manufacturer for this information. Check the company Web sites for MSDS information.

TABLE 1–2.
Safety Supply Companies in Ontario Providing Protective Clothing and Equipment

Company	Address	Phone/Fax	
3-M Canada Inc.	Occupational Health and Environmental Safety Box 5757 London, ON N6A 4T1	Tel: Fax:	(519) 452-6165 1-800-364-3577 (519) 452-4660
Acklands Grainger	90 W. Beaver Creek Rd. Richmond Hill, ON L4B 1E7	Tel: Fax:	(905) 731-5516 1-800-668-8989 (905) 731-2798
Aearo Canada	7115 Tomken Rd. Mississauga, ON L5S 1X7	Tel: Fax:	(905) 795-0700 1-800-387-4304 (905) 564-5250
Dutch Industries "Protect-Air Cab Filter"	Huron Tractor, Box 1300 Exeter, ON N0M 1S3	Tel: Fax:	(519) 235-1115 (519) 255-1939
HAMISCO	3392 Wonderland Rd. London, ON N6L 1A8	Tel: Fax:	(519) 652-9800 1-800-668-9800 (519) 652-9661
Kappler Canada	Box 1687 20 Ryan Place Brantford, ON N3T 5V7	Tel: Fax:	(519) 752-4369 1-800-387-9326 (519) 752-2161
Levitt-Safety (Eastern) Limited	2872 Bristol Circle Oakville, ON L6H 5T5	Tel: Fax:	(905) 829-3299 1-800-668-6153 (905) 829-2919
MSA Canada Inc.	148 Norfinch Dr. North York, ON M3N 1X8	Tel: Fax:	(416) 667-9400 1-800-267-0672 (416) 663-5908
Mitt & Robe Co.	751 Norfolk St. N. Simcoe, ON N3Y 3R6	Tel: Fax:	(519) 428-4050 1-877-893-6565 (519) 428-5142
Plant Products Co. Ltd.	314 Orenda Road Brampton, ON L6T 1G1	Tel: Fax:	(905) 793-7000 1-800-387-2449 (905) 793-9632
Safety Express	4060B Sladeview Cres., Unit 2 Mississauga, ON L5L 5Y5	Tel: Fax:	(905) 608-0111 1-800-465-3898 (905) 608-0091
The Saint George Company (Suppliers of Kasco Helmets)	206 McPherson School Rd. St. George, ON N0E 1N0	Tel: Fax:	(519) 442-2046 1-800-461-4299 (519) 442-7191

- When using fumigants or insecticide smoke generators, wear protective clothing to prevent skin and inhalation exposure.
- During and after treatment, lock the building and post warning signs.
- Follow instructions on the product label regarding aeration of treated buildings, warehouses, grain storage bins or other areas before letting anyone enter.

Fumigants

- An agriculturalist using methyl bromide plus chloropicrin or aluminum phosphide to fumigate greenhouses, vaults, warehouses and grain storages must obtain a permit issued under Ontario's *Pesticides Act.*
- To apply for a permit, contact the local pesticides officer with the Ontario Ministry of the Environment.
- Remove livestock and poultry that are in the same building.
- As a safety precaution, have someone else who is wearing personal protective equipment help with the fumigation.
- Always consult the product label.
- When handling methyl bromide, do not wear gloves because these will trap gas next to the skin.

Wear a full-face respirator with organic vapour canister or positive pressure breathing apparatus.

- When handling aluminum phosphide, use cotton gloves and wear a full-face mask respirator with an acid gas canister.
- For more information, obtain *Methyl Bromide Structure Fumigation Procedures* and *Aluminum Phosphide Structure Fumigation Procedures* from the Ontario Ministry of the Environment.

Storing Pesticides

- Ontario's *Pesticides Act* and Regulation 914 require that all pesticides be kept out of the reach of children, irresponsible persons, pets and livestock.
- Store pesticides in a locked facility away from food and feed.
- Store herbicides separately from other pesticides to avoid contamination.
- Always store pesticides in their original containers and keep them tightly closed.
- Never put pesticides in unmarked containers.
- In areas where flooding has been frequent, you must store fertilizers and pesticides above the known high-water mark. Contamination of water by these chemicals has led to serious health problems for humans and domestic animals as well as fish and wildlife.
- See also the OMAFRA Factsheet, *Pesticide Handling Facilities*, Order No. 94-037.

Schedule 1, 2 and 5 pesticides

- Schedule 1, 2 and 5 pesticides must be stored in a locked facility that is ventilated to the outside.
- A sign that says "CHEMICAL STORAGE WARNING — AUTHORIZED PERSONNEL ONLY" in block capitals must be affixed to the outside of each entrance.
- Only the certified agriculturalist or someone under that person's supervision can enter the storage facility.

Disposal of Pesticide Containers or Contaminated Material

- Either burn or dispose at a landfill site all paper or cardboard pesticide containers, paper packaging material or other paper material used to clean up spills.
- Keep people and animals away from the smoke and ensure the smoke is not directed toward buildings, highways, roads or outdoor public areas.
- Do not burn plastic material.
- Unrinsed containers can contain as much as 3% of the original formulation. If this amount of toxic pesticide is discarded with the container, it could be dangerous to people or the environment (for example, your water supply). Failure to rinse containers is also wasteful. Use that 3% for the reason you bought it — to control the pest!
- Rinse all metal, plastic or glass containers three times with water and add the washings to the spray tank. Rinsing devices can be used to puncture the bottom of a metal or plastic container and rinse the residue directly into the spray tank. This procedure takes less than a minute. Return the rinsed containers for recycling to any dealer co-operating in the pesticide container collection and recycling program.
- To dispose of unwanted or contaminated pesticide product:
  - Contact your local supplier. It is sometimes possible to return unused pesticide if it is still in its original container.
  - The Ministry of the Environment has an agreement with Safety-Kleen for the disposal of unwanted pesticides on a user-paid basis. Contact Safety-Kleen in London, Ontario, at (519) 451-6630 for disposal of unwanted or contaminated pesticides.
  - Contact a licensed waste hauler (licensed under the *Environmental Protection Act* (EPA) to carry hazardous waste) to arrange for disposal of your unwanted or contaminated pesticide. Check your local yellow pages under "Liquid Waste Removal" or "Waste Management" to arrange for proper disposal, or consult the local Ontario Ministry of the Environment office for additional information. Watch your local paper or trade publication for obsolete farm pesticides collection and disposal programs, or contact your dealer for further information. On these days, you can turn over surplus or unwanted pesticide concentrates (maximum 25L) for disposal at no cost.

Soluble Packaging Available

To simplify disposal of empty pesticide packages, the industry re-introduced a soluble package that dissolves in the tank of the farm sprayer. Water-soluble packaging under names such as Clean Pak, Solupak and Toss-N-Go is used for dry flowable and wettable powder formulations of pesticides.

In most cases, the water-soluble packaging material is PVA (poly vinyl alcohol). This material dissolves completely when added to the water in the sprayer tank according to instructions.

Handling

- Do not allow water-soluble pouches to become wet prior to adding them to the sprayer tank.
- Do not handle the pouches with wet hands or wet gloves.
- Do not remove water-soluble pouches from the overwrap (outer package) except when adding to the sprayer tank.
- Always reseal the outer package to protect the remaining pouches from moisture.

Mixing

- After the spray tank is one-quarter full of water and the agitator is running, add the water-soluble pouches to the tank.
- Depending on the water temperature and the degree of agitation, these pouches dissolve completely within 5 minutes.
- As the tank continues to fill, add any other compatible pesticides.
- Consult product labels for specific mixing instructions for each product.

Compatibility

- Do not add a pesticide that is incompatible with the PVA packaging material. The PVA material is not soluble with summer-type oils (e.g., Superior Oil).
- Do not combine with the pouches any material containing boron (e.g., Solubor), chelated micronutrients or water-soluble fertilizers. The combination is likely to cause a sticky, insoluble substance in the tank.
- After applying boron, chelated micronutrients or water-soluble fertilizers, completely empty and rinse the spray tank before using any product packaged in PVA.

Read all labels and instructions carefully. For more details, contact your farm chemical dealer.

Sprayers

- Herbicide sprayers that can deliver enough litres per hectare for adequate coverage are satisfactory for applying emulsion-type insecticides.
- If 2,4-D or related herbicides are used, clean the sprayers thoroughly with detergent containing ammonia to prevent crop damage.
- Adequate agitation is essential when applying wettable powder formulations.
- Pumps should be capable of delivering the flow and pressure required as well as being compatible with materials sprayed.
- Keep in mind that the higher the pressure, the greater the danger of drift to other crops.
- Calibrate your sprayer at least twice during the growing season with each set of nozzles used. The wear on nozzles and other parts will alter the amount of spray delivered.
- Check all nozzles for flow rate at least once a year. Replace nozzles when their output is 10% greater than rated output.
- For information on calibration, see the current OMAFRA Publication 75, *Guide to Weed Control.* See the calibration calculator on the OMAFRA Web site.

Ginseng Spray Technology

See the section *Sprayer Technology* on page 43.

Application by Airplane or Helicopter

- Aerial applicators must obtain a Commercial Aerial Applicators licence from the Ontario Ministry of the Environment to apply pesticides. They also need permits from the Ontario Ministry of the Environment to apply Schedule 1 and 5 pesticides and Schedule 2 hormone-type herbicides.
- Ministry personnel will inspect the area to ensure the application is done safely.
- It is an offence under the federal *Pest Control Product Act* and the provincial *Pesticides Act* to use a control product under unsafe conditions.
- Follow precautions at all times to prevent drift.
- Take extra precautions when using insecticides applied by air, especially those known to be toxic to honeybees, such as Sevin (carbaryl).
- Do not make applications if the wind is blowing. Even on the calmest day, some drift occurs.
- To keep pesticide drift to a minimum, make applications in the evening or early morning.
- Be sure that the contract specifies the product to be used and its rate of application. Aircraft may apply only products specifically allowing aerial use as outlined on the label.

Pesticide Drift

- Pesticide drift can leave residues on adjacent crops, be a hazard to nearby people and livestock, and reduce the amount of material in the target area so that it is ineffective.
- If applying pesticides, make every effort to minimize or prevent pesticide spray drift by doing one or more of the following:
  - read the product label
  - be aware of the toxicity of the pesticide being used
  - use buffer strips around water courses and neighbouring fields
  - select the correct water volume rate
  - use proper nozzle selection and, where practical, adopt use of air induction/venturi nozzles that significantly reduce drift compared to conventional nozzles
  - be aware of the weather conditions, including wind speed and direction
  - use spray plume protection where practical or available (hoods, shrouds, screens and air curtains)
  - use drift-reducing adjuvants
  - utilize wick weeders
  - select the correct nozzle-to-target distance
  - don't spray if conditions are not suitable

- Do not spray with conventional equipment during wind speeds greater than 10 km/hr if you have selected a low-volume, fine-mist spray output.
- It may be tolerable to spray in winds up to 20 km/hr if the spray droplets are mostly large, if there are adequate buffer zones around sensitive and residential areas to prevent off-site damage, and if best management practices are used to reduce drift.
- Growers are responsible for any material discharged from their sprayers no matter where it is found. This includes liability for adverse affects such as damage to crops or to ornamental plants, and illegal or unacceptable residue on neighbours' crops or property. You could also be responsible for injury resulting from car accidents caused by windows smeared by spray drift or allergic or asthmatic reactions of bystanders even if they are not on your property.
- Take all precautions necessary to prevent drift from the target site that might implicate you in any damaging action.
- For more information, consult the OMAFRA Factsheet, *Reducing Pesticide Drift and Crop Damage*, Order No. 00-103, the OMAFRA/Agriculture and Agri-Food Canada booklet *Best Management Practices — Pesticide Storage, Handling and Application* and the Ridgetown College video *How to Manage Spray Drift.*

Residues on Crops to Be Harvested, Fed or Grazed

- Some pesticide residues disappear quickly while others persist in poisonous concentrations.
- When crops with persistent residues are fed to livestock, the poisons may accumulate in the body fat, and milking cows will excrete them or their metabolic products in the milk. Young calves, heifers and dry cows can store them in body fat and secrete them when they freshen months later.

Bee Poisoning

- Honeybees, as well as other bees and insects, are important pollinators of crops. Many crops are significant sources of pollen for honey. It is therefore essential to refrain from poisoning bees foraging on these crops.
- Insecticides are required for insect control. With careful management, you can get good insect control without killing bees. The following are a few points to remember in preventing bee poisoning.
- Do not spray any flowering crop on which bees are foraging. If you must apply insecticides, spray in early morning or evening when bees are not foraging. Bees usually do not forage at temperatures below 13°C.
- If you must apply an insecticide poisonous to bees when they are foraging, notify neighbouring beekeepers so they can protect their bees.
- Do not apply insecticide on windy days to prevent drift toward any nearby hives.
- Remember that ground applications are generally less hazardous than aircraft applications and there is usually less drift.
- When there is a choice, choose the formulation less hazardous to bees. Dusts are more toxic than sprays. EC formulations are less toxic than WP formulations.
- Most organophosphate and carbamate insecticides are highly toxic to bees. Insecticides used in crop production that are toxic to bees are listed in Table 1–3, *Relative Toxicity of Insecticides to Honeybees,* on page 10.
- Other insecticides listed in this publication can be applied at any time with reasonable safety to bees. Consult individual product labels.
- When planning to apply a pesticide, advise local beekeepers so that they can move colonies out of the danger area. Contact the Provincial Apiarist at 1-888-466-2372 for a list of the beekeepers in your area.

TABLE 1–3.
Relative Toxicity of Insecticides to Honeybees

Group 1. **Very toxic. Do not apply to flowering crops or weeds**	
Pounce	permethrin
Basudin	diazinon
Cygon, Lagon	dimethoate
Guthion	azinphos-methyl
Imidan	phosmet
Lannate	methomyl
Lorsban	chlorpyrifos
Malathion	malathion
Ripcord, Cymbush	cypermethrin
Sniper	azinphos-methyl
Sevin	carbaryl
Group 2. **Apply only during late evenings or early morning.***	
Decis	deltamethrin
Dylox	triclorfon
Endosulfan, Thiodan	endosulfan
Relatively Non-Toxic	
All the fungicides	

* Unusually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during warm weather. High temperatures in the early morning or late evening may extend active foraging by bees.

Pesticide Concentration

- Brands of a pesticide from different companies often have different concentrations of the same chemical. If you use one with a concentration different from that listed in this publication, adjust the rate of application so you will be applying the same amount of actual chemical (active ingredient).

Pesticide Certification for Ontario Farmers

- Regulation 914 of the *Pesticides Act* makes it mandatory for farmers to be certified through the Grower Pesticide Safety Course to buy and use Schedules 1, 2 or 5 pesticides on land they farm.
- There must be at least one Certified Grower for each farm operation.
- Under the *Pesticides Act*, you are a grower (farmer) if you:
  - currently use farm land for agricultural or forestry production and
  - that farmland is classified as farmland property under Section 7 of the *Ontario Assessment Act*.

Training for Assistants Using Schedule 2 or 5 Pesticides

- As of January 2000, all assistants must have formal pesticide safety training, recognized by the Ministry of the Environment, before they can handle or use Schedule 2 or 5 pesticides under the supervision of a Certified Grower.
- This applies to all assistants, including family members, farm employees and seasonal workers.
- Trained Assistants do not have to write an exam.
- Trained Assistants must be 16 years of age or older.
- There are two training options for assistants. Assistants can:
  - attend a Grower Pesticide Safety Course and not write the certification examination, or
  - attend an on-farm training session presented by a qualified Trained Assistant Instructor.
- For more information and a listing of courses and exam-only session dates and locations, check the Ontario Pesticide Education Program Web site at www.ridgetownc.uoguelph.ca/opep/.
- To register for a Grower Pesticide Safety Course or GPSC Exam-Only Session (if you are renewing your certificate) or for information about Trained Assistants anywhere in Ontario, please:
  - call 1-800-652-8573 or (519) 674-1580, or
  - fax (519) 674-1589, or
  - e-mail opep@ridgetownc.uoguelph.ca

2. Soil Management and Fertilizer Use

Soil Testing

High yields can be produced efficiently only when fertilizer use is related to the fertility level of the soil and to other additions of nutrients in manure, crop residues, etc. At one extreme, on very low-fertility soils, it is occasionally profitable to add as much or more nitrogen, phosphorus or potassium through the fertilizer as a crop removes. At the other extreme, on high-fertility soils or following heavy application of manures, fertilizer use may not be profitable and may occasionally reduce yields.

Why Soil Test?

Ask for OMAFRA-accredited soil tests. They are the most accurate tool available to Ontario farmers to determine the amounts of phosphorus, potassium and magnesium fertilizers and lime that should be applied for crop production.

Other Methods of Assessing Nutrient Needs

1. Plant analysis is the main tool used for tree fruits and can serve as additional information supporting the soil test for field and vegetable crops.

2. Nutrient deficiency symptoms on crop leaves are helpful in some cases but have serious drawbacks in others, particularly with potassium and phosphorus.

3. It is occasionally suggested that a farmer apply the amounts of nutrients removed by the crop. This has some application for nitrogen, as with some crops, the suggested rate approximates what the plant removes. It has little relevance for other nutrients in Ontario. Some of our clay and clay loam soils have enough potassium to last many years, and application of potassium each year on those soils is a waste of money and ignores one of the few advantages that clay soils have over coarser-textured soils.

TABLE 2–1.
OMAFRA-Accredited Soil Tests

Materials Analyzed	What Is Analyzed[1]
Soils for field crops, commercial turf, etc.	Plant-available phosphorus, potassium, magnesium, manganese and zinc; pH; lime requirement
Greenhouse media	Plant-available nitrogen, phosphorus, potassium, calcium, magnesium; pH; total salts
Nutrient solutions, water	Plant-available nitrogen, phosphorus, potassium, calcium, magnesium; pH; total salts; sulphates; chlorides

Consult a resource centre of the Ontario Ministry of Agriculture, Food and Rural Affairs for a list of accredited laboratories and their prices. See Appendix E, on page 69.

[1] Soil organic matter tests can be useful for herbicide recommendations but are not accredited tests.

The OMAFRA-accredited soil testing program is the main guide along with help from plant analysis and nutrient deficiency symptoms in determining your fertilizer requirements for a specific crop on a specific field. See Table 2–1, *OMAFRA-Accredited Soil Tests,* above.

What Does the OMAFRA-Accredited Soil Testing Program Provide for the Farmer?

The OMAFRA-accredited soil testing program provides recommendations for nitrogen, phosphate, potash and magnesium fertilizer, along with recommendations for the amount and type of lime you should apply. The OMAFRA-recommended fertilizer rates are provided in this publication. They are designed to produce the highest economic yields when accompanied by good or above-average management. Research shows that higher rates will occasionally produce higher yields but that these increases in yield are likely to be small and not profitable. Some fertilizer is recommended at soil test levels slightly above those where crop response is profitable. This is done to maintain high soil-nutrient levels and to allow for some error in sampling the field. For high-value crops such as tobacco, the maximum profit we aim for will require essentially the same amount of fertilizer as maximum crop value (maximum yield with high quality). For low-value crops, there may on occasion be a slight yield response to rates of fertilizer above those recommended for maximum profit. However, trials on farm fields with corn have shown no yield response to rates of fertilizer above those recommended by soil test. Further assistance in interpreting soil test reports is available from the field offices of the Ontario Ministry of Agriculture, Food and Rural Affairs.

Refer to Appendix E, *Accredited Soil Testing Labs in Ontario*, on page 69, for a list of accredited labs.

Soil Tests From Other Laboratories

Each year a number of farmers ask OMAFRA staff to interpret results from laboratories that are not accredited. Provided the other laboratory uses the identical test used by the OMAFRA-accredited service and expresses their test results in the same units, the OMAFRA fertilizer requirements for phosphate and potash can be determined.

Only OMAFRA-accredited soil tests can be relied on to provide accurate fertilizer recommendations. Be certain that the service you are using is accredited. To be accredited, a laboratory must use OMAFRA-approved testing procedures, must demonstrate acceptable analytical precision and accuracy and must provide the OMAFRA fertilizer recommendations.

A number of laboratories provide soil tests that are not accredited by OMAFRA, such as exchange capacity, aluminum and copper. These are not accredited by OMAFRA because they have not been found to contribute to better fertilizer recommendations. Research has shown that on Ontario soils, use of exchange capacity to adjust potash recommendations can lead to less reliable recommendations than are now provided.

Soil Sampling

Soils may be sampled with a sampling tube or with a shovel. Each field or uniform section of a field should be sampled separately. At least 20 soil cores 15 cm deep should be taken from any field or area sampled up to 5 ha in size. For fields larger than 5 ha, proportionately more cores should be taken. The more cores taken, the more likely the soil sample is to provide a reliable measure of the fertility in the field. One sample should not represent more than 10 ha.

The soil can be collected in a clean pail; the lumps should be broken, the soil mixed well and a soil sample box forwarded for testing. The area sampled should be traversed in a zigzag pattern to provide a uniform distribution of sampling sites. Parts of a field that differ in appearance of soil or crop, or in previous fertilization, manuring or liming should be sampled separately, even if they are too small to fertilize separately. Avoid sampling recent fertilizer bands, dead furrows or areas adjacent to gravel roads or where lime, manure, compost or crop residues have been piled.

When to Sample

Each field should be sampled once every two or three years. Potash levels can change quickly where large amounts of nutrients are removed from sandy soils (for example, with crops such as alfalfa hay, corn silage, potatoes or tomatoes) and are not returned. Under these conditions, samples should be taken each year.

To allow time for mailing and analysis, soil samples from fields to be fertilized for spring seeding crops should be taken the previous fall. Because of the rush of harvest and the frequency of poor weather late in the fall, summer may be a more convenient time to sample for some farmers.

Ginseng growers usually prepare land for ginseng one to two years in advance of seeding. Ginseng is seeded in the fall. Under these circumstances, land to be used for ginseng production should be tested in the fall prior to the preplant year. If adjustments to pH and/or fertility are made, additional testing should be done in the summer of the preplant year (see Table 2–8, *Adjustment of Nitrogen Requirement Where Crops Containing Legumes Are Ploughed Down*, on page 17).

Information on Accredited Labs

A list of accredited laboratories and information on the cost of various tests may be obtained from any resource centre of the Ontario Ministry of Agriculture, Food and Rural Affairs or refer to the OMAFRA Web site at http://www.gov.on.ca/omafra.

Factors that affect a soil-test recommendation are manure application, ploughing down of legume sod and crop to be fertilized. This information is essential for a reliable fertilizer recommendation and should be recorded on the field information sheet, which must accompany the soil sample sent in for analysis.

Plant Analysis

Plant analysis measures the nutrient content of plant tissue. Comparing the results against the "normal" and "critical" values for the crop can indicate whether nutrient supply is adequate for optimum growth.

Plant analysis is the basis of fertilizer recommendations for tree fruits and grapes, and is a useful supplement to soil testing for evaluation of the fertility status of other crops. It is quite independent of soil testing and can provide a valuable "second opinion," especially for phosphorus, potassium, magnesium and manganese. For nitrogen and zinc, it has not been very reliable. For boron and copper, there is not a reliable soil test, so plant analysis and visual symptoms are the methods used for diagnosing deficiencies. This is particularly important for ginseng growers to recognize. Ginseng can suffer from boron toxicity (see PLATE 93 on page 88). Leaf analysis is the only way to determine if excessive levels of boron exist in ginseng.

Plant analysis has limitations. Expert help in interpreting the results is often needed since plant analysis does not usually indicate the cause of a deficiency or the amount of fertilizer required to correct it.

Sampling

Time of sampling has a major effect on the results since nutrient levels within a plant vary considerably with the age of the plant. Results are difficult to interpret if samples are taken at times other than those recommended. Nevertheless, plants suspected of being nutrient deficient should be sampled as soon as a problem appears. Samples are best taken from a problem area rather than from the entire field.

Samples for plant analysis should be taken from at least 20 plants distributed throughout the area chosen for sampling. Each sample should consist of at least 100 grams of fresh material. Problem areas should be sampled separately. When taking samples for plant analysis, take care not to contaminate the sample with soil. Even a small amount of soil will cause the results to be invalid, especially for micronutrients.

Sampling in ginseng should be done after the plants reach full canopy, usually early to mid-July. Sampling during leaf expansion will be variable and inaccurate. Nutrient levels in ginseng leaves may be affected by flowering and seed development and by deflowering. If nutrient deficiencies or toxicities are suspected, samples should be taken from good and bad areas in gardens at the same stage of development. Leaf sampling in ginseng should always accompany soil sampling.

Sample Preparation

Samples of fresh plant material should be delivered directly to the laboratory. If they cannot be delivered immediately, they should be dried to prevent spoilage. Samples may be dried in an oven at 65°C or less or dried in the sun, provided precautions are taken to prevent contamination with dust or soil. Avoid contact of samples with galvanized (zinc-coated) metal, brass or copper.

Plant analyses may be obtained from several laboratories in Ontario.

Micronutrient Tests

OMAFRA-accredited tests are available for manganese and zinc. In the case of zinc on corn, the soil test is best used in conjunction with visible deficiency symptoms. With manganese, plant analysis, visible symptoms and the soil test are all useful. OMAFRA-accredited tests are not available for boron, copper, iron or molybdenum. Plant analysis is generally a better indicator of deficiencies of these nutrients.

Contamination

Great care is required to prevent contamination of soil samples with micronutrients, particularly zinc. Do not use galvanized (zinc-plated) soil sampling tubes to take soil samples for micronutrient tests. Do not use metal containers to collect and mix samples. Clean plastic containers in good condition should be satisfactory. Soil samples that have contacted galvanized surfaces are unsatisfactory for zinc soil tests. Be careful to keep dust around buildings, etc., out of the samples.

Soil Sampling

Micronutrient deficiencies frequently occur in small patches in fields. In these cases, analysis of soil or plant material taken from the entire field is unlikely to find the problem. Sample problem areas separately.

Fertilizer Recommendations

Soil Acidity and Liming

The pH scale ranging from 0 to 14 is used to indicate acidity and alkalinity. A pH value of 7.0 is neutral, values below 7.0 are acid, and those above 7.0 are alkaline. Most field crops grow well in a soil pH range from 6.0 to 8.0.

TABLE 2–2.
Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH

Ground limestone required tonne/ha
(Based on an Agricultural Index of 75)

Buffer pH	Target soil pH = 6.5 (Lime if soil pH below 6.1)	Target soil pH = 6.0 (Lime if soil pH below 5.6)	Target soil pH = 5.5 (Lime if soil pH below 5.1)
7.0	2	1	1
6.9	2	1	1
6.8	2	1	1
6.7	2	2	1
6.6	3	2	1
6.5	3	2	1
6.4	4	3	2
6.3	5	3	2
6.2	6	4	2
6.1	7	5	2
6.0	9	6	3
5.9	10	7	4
5.8	12	8	4
5.7	13	8	5
5.6	15	11	6
5.5	17	12	8
5.4	19	14	9
5.3	20	15	10
5.2	20	17	11
5.1	20	19	13
5.0	20	20	15
4.9	20	20	16
4.8	20	20	18
4.7	20	20	20
4.6	20	20	20

To correct soil acidity, ground limestone should be broadcast and worked into the soil at rates determined by soil test.

The Buffer pH

Different soils with any one soil pH value, say 5.2, will require different amounts of lime to bring the pH to a particular desired level, say 6.0, depending chiefly on the clay and organic matter content of each soil. The soil pH is used to determine which soils need to be limed but a separate soil test, the buffer pH, is run on soils needing lime to determine the amount of lime required. For soils needing lime (based on soil pH), Table 2–2, *Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH*, above, may be used to determine the amount of lime required to reach different "target" soil pH values required for different crops.

TABLE 2–3.
Example Calculation of the Fineness Rating of a Limestone

Particle Size	% of Sample	x	Effectiveness Factor	=	Fineness Rating
Coarser than #10 sieve[1]	10	x	0	=	0
#10 to #60 sieve	40	x	0.4	=	16
Finer than #60 sieve	50	x	1.0	=	50
Fineness Rating of Whole Sample					66

[1] A #10 Tyler sieve has wires spaced 2.0 mm apart.

Limestone Quality

Calcitic limestone consists largely of calcium carbonate, and dolomitic limestone is a mixture of both calcium and magnesium carbonates. Dolomitic limestone should be used on soils with a magnesium soil test of 100 or less, as it is an excellent and inexpensive source of magnesium for acid soils. On soils with magnesium tests greater than 100, calcitic or dolomitic limestone may be used.

Two main factors affect the value of limestone for soil application. One of these is the amount of acid a given quantity of limestone will neutralize when it is totally dissolved. This is called the "neutralizing value" and is expressed as a percentage of the neutralizing value of pure calcium carbonate. A limestone that will neutralize 90% as much acid as pure calcium carbonate is said to have a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the higher the neutralizing value.

The second factor that affects the value of limestone as a neutralizer of acidity is the particle size. Limestone rock has much less surface area to react with acid soil than finely powdered limestone and, hence, neutralizes acidity much more slowly — so slowly that it is of little value. The calculation of a fineness rating for ground limestone is illustrated in Table 2–3, *Example Calculation of the Fineness Rating of a Limestone*, above.

The Agricultural Index

Some means of combining the Neutralizing Value and the Fineness Rating is needed to compare various limestones that are available. The index that has been developed in Ontario to do this is called the "Agricultural Index."

$$\text{The Agricultural Index} = \frac{\text{neutralizing value x fineness rating}}{100}$$

The Agricultural Index can be used to compare the relative value of different limestones for neutralization of soil acidity. Lime with a high Agricultural Index is worth proportionately more than lime with a low Index because it may be applied at a lower rate. If two ground limestones, A and B, have Agricultural Indices of 50 and 80 respectively, the rate of application of limestone A required for a particular soil will be 80/50 x the rate required for limestone B. Limestone A spread on your farm is worth 50/80 x the price of limestone B per tonne.

Recommendations from the OMAFRA soil test service are based on limestone with an Agricultural Index of 75. If you know the Agricultural Index, you can calculate a rate of application specifically for limestone of that quality. This can be done using the following equation:

$$\begin{array}{c}\text{Limestone}\\\text{application rate}\\\text{from soil test}\end{array} \times \frac{75}{\begin{array}{c}\text{Agricultural Index}\\\text{of your limestone}\end{array}} = \begin{array}{c}\text{Rate of}\\\text{application of}\\\text{your limestone}\end{array}$$

For example, if you have a limestone requirement by soil test of 9 t/ha and your most suitable source of limestone from a quality and price standpoint has an Agricultural Index of 90, you should apply 75/90 x 9 = 7.5 t/ha.

The Agricultural Index does not provide information about magnesium content. Dolomitic limestone should be used on soils low in magnesium.

Tillage Depth

Lime recommendations presented here should raise the pH of the top 15 cm of a soil to the listed target pH. If the soil is ploughed to a lesser or greater depth than 15 cm, proportionately more or less lime is required to reach the same target pH. Where reduced tillage depths are used, rates of application should be reduced proportionately. More frequent liming will be needed.

Lowering Soil pH

On soils with pH values below 6.5, it is possible to lower the pH (make the soil more acid) by adding sulphur or ammonium sulphate. This may be desirable for some crops, for example, potatoes for scab control, but usually will not be suitable for rotation crops. Soil pH cannot be made to flip-flop from a low pH to a more moderate pH from year to year. If the soil pH is above 6.5, it is not advisable and also usually quite impractical to lower it because of the very large amounts of sulphur or ammonium sulphate required.

TABLE 2–4.
Phosphorus Requirements for Ginseng on Mineral Soils

Soil Phosphorus (ppm P)	Rating	Phosphate (P_2O_5) Required kg/ha
0–3	L	80
4–5	L	60
6–7	L	50
8–9	L	40
10–12	M	30
13–15	M	20
16–20	H	0
21–25	H	0
26–30	VH	0
31–40	VH	0
41–50	VH	0
51–60	VH	0
61–80	E	0
80 +	E	0

Nitrogen

Research is currently under way to determine the nitrogen requirements of ginseng. Ginseng is a native plant of the forest floor, so its nitrogen requirements will differ significantly from those of field crops.

Phosphate and Potash

Phosphate and potash recommendations are based on OMAFRA-accredited soil tests (see Table 2–4, *Phosphorus Requirements for Ginseng on Mineral Soils*, above, and Table 2–5, *Potassium Requirements for Ginseng on Mineral Soils*, on page 16). These tables should be used only with OMAFRA-accredited soil tests.

Where a soil test is not available, a rough estimate of requirements can be obtained from these tables using the following guidelines:

- Where the field has been fertilized regularly for a number of years or heavily in recent years, use one of the rates of phosphate and potash recommended for the MEDIUM soil test rating.
- If the field has received little fertilizer in the past, use one of the rates recommended for a LOW soil test rating.

TABLE 2–5.
Potassium Requirements for Ginseng on Mineral Soils

Soil Potassium (ppm K)	Rating	Potash (K_2O) Required kg/ha
0–15	LOW	230
16–30	LOW	220
31–45	LOW	200
46–60	LOW	180
61–80	LOW	140
81–100	LOW	100
101–129	MEDIUM	70
121–150	MEDIUM	50
151–180	MEDIUM	40
181–210	HIGH	0
211–250	VERY HIGH	0
250 +	EXCESSIVE	0

Soils testing excessive (E) for phosphorus contain much more plant-available phosphorus than required for most crops. Applications of phosphorus fertilizers, compost, manure, sewage sludge or other sources of phosphorus to these soils should be avoided because of the increased risk of water pollution.

Some clay and clay loam soils are naturally high in potassium and do not require any potash fertilizers. Only a soil test can adequately determine potash requirements.

Magnesium

Magnesium is a plant nutrient that is naturally plentiful in many Ontario soils. Soils with magnesium soil tests below 20 (OMAFRA soil test) require magnesium application for the production of most crops. Very few Ontario soils have magnesium tests below 20. If the soil pH is below 6.0, the most effective and inexpensive means of supplying magnesium is by the application of dolomitic lime. If the pH is above 6.0, and the soil test 20 or below, magnesium can be supplied through either magnesium sulphate or sulphate of potash magnesia, which is a mixture of sulphate of potash and magnesium sulphate. Apply 30 kg/ha of actual soluble magnesium. These latter sources of magnesium are usually quite expensive compared to supplying magnesium from dolomitic limestone.

Potassium competes with magnesium for uptake by crops, and potash applications can therefore induce or increase magnesium deficiency. For this reason, it is important to monitor soil potassium levels and to carefully control potash fertilizer applications on low-magnesium soils.

TABLE 2–6.
Manganese Soil Test Interpretation

Manganese Soil Test[1]	Suggested Treatments
greater than 30	Soil manganese availability is adequate for field-grown crops.
16 to 30	Soil manganese availability is adequate for many crops but is approaching deficiency levels for oats, barley, wheat and soybeans. If deficiency symptoms appear, spray with manganese. Consider a re-check for deficiency using plant analysis.
less than 16	Soil manganese availability is believed to be insufficient for oats, barley, wheat and soybeans. Spray with manganese at the four-leaf stage and again 3 weeks later, if required. Manganese deficiency has not been diagnosed on corn in Ontario, even on soils that are very deficient for wheat.

[1] These values are indices of manganese availability based on extractable soil manganese and soil pH.

Crops grown on a number of Ontario soils are low in magnesium to an extent that livestock health is affected, although the crops themselves do not suffer from magnesium deficiency. In these situations, it is usually much less costly to add magnesium to the animal's diet than to add it to the soil. Soil potassium should be closely monitored, however, and potash applications restricted to requirements as measured by soil test.

Calcium deficiency has not been a problem in Ontario soils with soil pH adequate for field crop growth. Adequate soil pH is a reliable indicator of adequate calcium in the soil.

Micronutrient Fertilizers

Micronutrient elements should not be combined with insecticide or fungicide sprays unless the manufacturer's directions indicate that this may be done or experience has shown that they are compatible.

Micronutrient elements should be applied only on competent advice or where experience has proven their application to be necessary. Soil or foliar applications

TABLE 2–7.
Zinc Soil Test Interpretation

Zinc Soil Test[1]	Suggested Treatments
greater than 200	You should suspect contamination of the sample or of the field.
25 to 200	Soil zinc availability is adequate for most field-grown crops.
15 to 24	Zinc availability is adequate for most field crops but is bordering on deficiency for corn. If the field sampled is uneven in soil texture, pH or erosion, some areas may respond to zinc applications. Deficiency symptoms at the 4–6-leaf stage are a reliable indication of zinc deficiency (see the OMAFRA Factsheet, *Zinc Requirements for Field Crops*, 100/531).
less than 15	Zinc is likely to be deficient for corn and should be applied in the fertilizer.

[1] These values are indices of zinc availability based on extract able soil zinc and soil pH.

can be made. Soil applications are generally made at soil-preparation time, and foliar applications are applied during the growing season. A sticker spreader should be included in micronutrient sprays.

Preventing and Correcting Manganese Deficiency

Manganese is less available at high soil pH, so it is important not to add more lime than is needed to correct soil acidity. Interpretation of the manganese soil test is found in Table 2–6, *Manganese Soil Test Interpretation*, on page 16.

Preventing and Correcting Zinc Deficiency

High phosphorus in the soil and/or in the fertilizer can cause or increase the severity of zinc deficiency. *Apply only the recommended amount of phosphorus.* Use of animal manures can prevent or reduce zinc deficiency. Erosion control can prevent deficiency of zinc by maintaining the topsoil.

Zinc deficiency can be prevented by application of zinc fertilizer to the soil. Foliar sprays can be useful for correcting a deficiency after the symptoms have appeared, provided this is done early in the growing season. Interpretation of the zinc soil test is found in Table 2–7, *Zinc Soil Test Interpretation*, above.

TABLE 2–8.
Adjustment of Nitrogen Requirement Where Crops Containing Legumes Are Ploughed Down

Type of Crop	For All Crops, Deduct From N Requirement kg N/ha
Less than 1/3 legume	0
1/3 to 1/2 legume	55
1/2 or more legume	100
Perennial legumes seeded and ploughed in the same year	45[1]
Soybean and field bean residue	0

[1] Applies where the legume stand is thick and over 40 cm high.

Copper soil tests are quite unreliable on Ontario soils, but plant analysis is useful. Copper is unlikely to be deficient in mineral soil, except perhaps in very sandy soils. Copper deficiency does occur in organic soils and is best diagnosed by plant analysis. When organic soils are first brought into cultivation, copper should be applied to the soil at 14 kg/ha for each of the first three years.

Boron is required on some soils. Boron deficiency usually occurs in dry weather so that response is erratic. Thus it has not been possible to develop a reliable soil test. Plant analysis is useful as a predictor of boron requirements as are visible symptoms on the plants.

Because boron is needed only in very small quantities, and since an overdose is toxic, extreme care should be taken in its use. Boron deficiency has not been diagnosed in cereals, peas and beans in Ontario, and boron applications to these crops or to other crops in the year preceding them can be toxic. *Boron should not be banded.*

Iron and molybdenum have not been found to be deficient in field crops in Ontario.

Adjustments to Fertilizer Recommendations

Adjustment for Legumes Ploughed Down

When sod containing perennial legumes such as alfalfa, trefoil and clover are ploughed under, they supply an appreciable amount of nitrogen to the following crop. Table 2–8, *Adjustment of Nitrogen Requirement Where Crops Containing Legumes Are Ploughed Down*, above, shows reductions that should be made in nitro-

TABLE 2–9.

Average Amounts of Available Nutrients for Different Types of Manure

Nutrient values based on average analysis results for over 700 samples. There are large variations between different manures, so a manure analysis is your best guide to nutrient availability.

Manure	Average Dry Matter	Available Nitrogen[1] Spring 1 day	Available Nitrogen[2] Spring not incorporated	Available P_2O_5[3]	Available K_2O[4]
kg/1,000 L					
liquid dairy	6.5%	1.6 (16)	0.6 (6)	0.7 (7)	3.0 (30)
liquid hog	3.6%	2.6 (26)	0.7 (7)	1.1 (11)	2.0 (20)
liquid poultry	8.0%	6.1 (61)	1.7 (17)	2.5 (25)	3.4 (34)
liquid biosolids (sludge)[5]	4.4%	1.2 (12)	0.6 (6)	1.3 (13)	0.2 (2)
kg/tonne					
solid biosolids	36%	1.5 (3)	0.75 (1.5)	11.0 (22)	0 (0)
solid poultry	49%	11.5 (21)	6.0 (12)	9.0 (18)	12.5 (25)
solid dairy	20%	1.5 (3)	0.7 (1.4)	1.5 (3)	5.5 (11)
solid beef	27%	1.5 (3)	0.75 (1.5)	1.5 (3)	7.0 (14)

1,000 gallons/acre = 11,230 L/ha; 1 ton/acre = 2.25 t/ha. See Appendix G, *The Metric System*, on page 71, for other conversions.

[1] Nitrogen based on spring application, incorporated within 24 hours.

[2] Nitrogen based on spring application, not incorporated (i.e., on soil surface for over 7 days).

[3] Phosphate from manure or biosolids is assumed to be 40% as available as that in manufactured fertilizer in the year of application.

[4] Potash from manure or biosolids is assumed to be 90% as available as that in manufactured fertilizer in the year of application.

[5] For biosolids (e.g., sewage sludge), you must get a certificate of approval from your local MOE office. This can take up to 6 months.

gen fertilizer applications to crops following sod containing legumes.

Manure

A large number of Ontario farms produce livestock, generating over 33 million tonnes of manure. Proper management of the nutrients from manure is essential for optimum economic benefit to the farmer with minimal impacts on the environment. See Table 2–9, *Average Amounts of Available Nutrients for Different Types of Manure*, above.

In ginseng, manure should be applied no later than 4–6 weeks prior to fumigation.

Manure Analysis

Manure analysis is necessary because the quantities of nutrients contained in manure vary from farm to farm, especially the phosphorus and potash components. Type of livestock, ration, bedding, added liquids and storage system all affect the final nutrient analysis.

There are two nitrogen components in manure. Ammonium-nitrogen makes up the largest percentage of the nitrogen in liquid manure, with approximate percentages listed by livestock type in Table 2–10, *Approximate Ammonium-Nitrogen Levels Available by Livestock Type*, on page 19. The organic nitrogen component is available over time as the organic matter breaks down. About 30% of the organic nitrogen component of manure is assumed to be available to a growing crop. The percentage is generally higher in poultry and lower for ruminant manure.

Ammonium-nitrogen is immediately available to a growing crop but is also most easily lost to volatilization unless incorporated soon after application. Soil moisture and weather conditions will determine how quickly and how much loss to expect. These losses are highest during sunny, high-temperature days when soils are dry; losses are lowest when conditions are overcast and cold, and soils are moist, or during rainy periods. Table 2–11, *Estimated Percentage of Ammonium-Nitrogen Lost Due to Weather and Soil Conditions*, on page 19, gives estimated losses due to weather and soil conditions.

Long-Term Value of Manure

The long-term availability of phosphorus (P), potassium (K), magnesium, zinc or manganese from previous

TABLE 2–10.
Approximate Ammonium-Nitrogen Levels Available by Livestock Type
(expressed as % of total manure N)

Manure Type	Ammonium-N
liquid poultry	75%
liquid hog	62%
liquid beef	60%
liquid dairy	50%
biosolids (sewage sludge)	27%
solid hog	30%
solid poultry	30%
solid dairy	25%
solid beef	12%

manure applications is best estimated by soil testing. Application of large quantities of manure over time can result in high levels of available P and K in soils. Manures also contribute other plant nutrients and organic matter to soil that may be of some long-term value.

Most of the available nitrogen in manures is used by the crop or is lost during the first growing season following application. The remaining organic nitrogen becomes available in small, diminishing quantities in the succeeding years. Generally, the amount of residual nitrogen from one application is too small to make a practical difference in nitrogen recommendations for a crop. However, where solid manure is applied regularly to the same field, there can be significant residual nitrogen available for a crop. The N soil test for corn or barley can be used to assess available nitrogen in succeeding years following application. The soil test for P and K should be used to measure residual phosphorus and potassium from manure applications.

Crop Requirements

Residual nitrogen from legume crops should be taken into account when determining additional nitrogen needs from manure or fertilizer (see Table 2–8, *Adjustment of Nitrogen Requirement Where Crops Containing Legumes Are Ploughed Down*, on page 17).

Biosolids

Off-farm-sourced biosolids (for example, sludge from municipal sewage treatment plants) can be a useful source of nutrients and organic matter. Guidelines are available from OMAFRA and MOE. A Certificate of Approval for land application is required and is available from MOE. An analysis of nutrients applied should be given by the applicator to the landowner whenever biosolids are applied.

TABLE 2–11.
Estimated Percentage of Ammonium-Nitrogen Lost Due to Weather and Soil Conditions

	Cool (<10°C)		Warm (>25°C)	
	wet	dry	wet	dry
Incorporated				
injected in season	0	0	0	0
incorporated within 1 day	10	15	25	50
incorporated within 2 days	13	19	31	57
incorporated within 3 days	15	22	38	65
incorporated within 4 days	17	26	44	73
incorporated within 5 days	20	30	50	80
Not Incorporated				
Spring/Summer/Early Fall				
bare soil	40	50	75	90
crop residue	30	35	60	70
standing crop	20	25	40	50
Late Fall (air temp <10°C)	25	25	N/A	N/A

adapted: Beauchamp, 1995

The OMAFRA Factsheet, *Land Application of Sewage Biosolids for Crop Production*, Order No. 95-069, is available as a reference.

Calibrating Spreaders

Calibrating manure application equipment is essential. Several methods can be used to measure spreading rates. Weighing a load of manure and measuring the area that load covers is one method of estimating the rate. Solid manure can be weighed by placing plastic sheets on the ground and liquid manure by using straight-walled pails for measuring depth of application. Overlap should also be considered, especially in irrigation systems. Table 2–12, *Calibrating Manure Spreaders*, on page 20, gives an estimate of application rates while Table 2–13, *Densities of Different Types of Manure*, on page 20, distinguishes between the densities of different types of manure. The OMAFRA Factsheet, *How to Calibrate Your Liquid Manure Spreader*, Order No. 97-003, is available as a reference.

TABLE 2–12.
Calibrating Manure Spreaders

Solid Manure Calibration Using a 40"x 48" sheet (plastic feedbag)		Liquid Manure Calibration Using a Straight-Walled Pail	
Pounds of Manure (per sheet)	**Application Rate (tons/acre)**	**Depth of Manure (in. in pail)**	**Application Rate (gal/acre)**
1	1.6	1/10	2,265
2	3.2	1/8	2,825
3	4.8	1/4	5,650
4	6.4	3/8	8,500
5	8.0	1/2	11,325
7	11.2	5/8	14,150
10	16.0	3/4	17,000
15	24.0	1	22,650

Environmental Concerns With Manure

Spreading manure in the winter and early spring is not recommended because of the potential for runoff to surface water. The fate of the first meltwater following manure application determines whether this will be a problem or not. This practice should not be incorporated into a nutrient management plan. In years when winter spreading may be necessary, care must be taken to select fields where there is no risk of runoff to surface water.

Rain can cause organic nitrogen to wash into streams if manure has been applied to unprotected cropland. Phosphorus attached to soil particles can be carried to streams by soil erosion. Conservation practices can reduce the chances of nutrients polluting waterways.

Manure should not be applied near watercourses. Runoff potential is influenced by field slope and soil texture. Use Table 2–14, *Determining Minimum Separation Distance From Watercourses,* right, to determine the runoff potential to establish a safe minimum separation distance. In a no-till system that includes a 10-ft-wide buffer strip along the watercourse, the separation distance can be reduced to 30 ft for liquid manure and 15 ft for solid manure.

Flow in tile drains can become contaminated if manure enters a catchbasin or travels through soil cracks to the tiles. With liquid manure, maintain a 30-ft buffer around a catchbasin or surface inlet (15 ft with solid manure). If there is any history of tile contamination via soil cracks or macropores, tillage prior to application is recommended.

TABLE 2–13.
Densities of Different Types of Manure

Manure Type	Weight per cubic foot	Weight per cubic metre
Liquid	62.4 lb	1,000 kg
Semi-solid	60.0 lb	960 kg
Thick solid	50.0 lb	800 kg
Light solid	35.0 lb	560 kg

one bushel = 1.25 cubic feet

Applications of nutrients in manure or fertilizer in excess of crop requirements can result in contamination of groundwater, particularly on shallow soils over bedrock, soils with a water table close to the surface or very sandy soils where leaching is a concern. Groundwater contamination can occur by mass flow through cracks and holes to groundwater or through leaching of nitrates through the soil.

TABLE 2–14.
Determining Minimum Separation Distance From Watercourses

Runoff Potential

	Field Slope within 500 ft of watercourse			
Soil Texture	**<0.5%**	**0.5%–2%**	**2%–5%**	**>5%**
Sand	Very Low	Very Low	Very Low	Low
Loam	Very Low	Low	Low	Moderate
Clay loam	Low	Moderate	Moderate	High
Clay	Moderate	High	High	High

Use the runoff potential to determine the minimum separation distance.

Minimum Separation Distance

Runoff Potential	Surface Applied		Incorporated or Pre-tilled	
	Liquid	**Solid**	**Liquid**	**Solid**
High	100 ft	50 ft	60 ft	30 ft
Moderate	75 ft	37 ft	45 ft	22 ft
Low	50 ft	25 ft	30 ft	15 ft
Very Low	30 ft	15 ft	30 ft	15 ft

Nutrient Management Practices BMP

TABLE 2–15.
Fertilizer Materials — Primary Nutrients

Nitrogen Materials	Form	% Nitrogen (N)
Ammonium nitrate	Dry	30 to 34
Calcium ammonium nitrate	Dry	27
Urea	Dry	45 to 46
Ammonium sulphate	Dry	20
Aqua ammonia	Liquid[1]	20
Ammonium nitrate-urea	Liquid	28
Ammonium nitrate-urea	Liquid	32
Ammonia-ammonium nitrate-urea	Liquid[1]	41
Ammonia-ammonium nitrate	Liquid[1]	41
Anhydrous ammonia	Liquid[1]	82
Phosphate Materials	**% Phosphate (P_2O_5)**	
Single superphosphate	20	
Triple superphosphate	44 to 46	
Monoammonium phosphate	48 to 52	
Diammonium phosphate (18-46-0)	46	
Potash Materials	**% Potash (K_2O)**	
Muriate of potash	60 to 62	
Sulphate of potash	50	
Sulphate of potash magnesia (11% Mg)	22	
Potassium nitrate (13-0-44)	44	

[1] Liquid under pressure.

TABLE 2–16.
Fertilizer Materials — Secondary and Micronutrients

Magnesium (Mg)	
Dolomitic limestone	6–13% Mg
Epsom salts (magnesium sulphate)	10.5% Mg
Sulphate of potash magnesia	11% Mg
Boron (B)	
Sodium borate	12–21% B
Solubor	20.5% B
Copper (Cu)	
Copper sulphate	13–25% Cu
Copper chelates	5–13% Cu
Manganese (Mn)	
Manganese sulphate	26–28% Mn
Molybdenum (Mo)	
Sodium molybdate	39% Mo
Zinc (Zn)	
Zinc sulphate	36% Zn
Zinc chelates	7–14% Zn
Zinc oxysulfate	18–36% Zn

Fertilizer Materials

Please see Table 2–15, *Fertilizer Materials — Primary Nutrients*, and Table 2–16, *Fertilizer Materials — Secondary and Micronutrients*, above.

Soluble Salts in Farm Soils

High concentrations of water-soluble salts in soils can prevent or delay germination of seeds and can kill established plants or seriously retard their growth.

Ontario soils are naturally low in soluble salts. Soluble salts therefore rarely cause a problem in crop production and are not routinely measured in soil tests.

Soluble salts in soils can result from excessive applications of fertilizers and manures, runoff of salts applied to roads and chemical spills on farmland. High concentrations of soluble salts in or near a fertilizer band can cause serious early plant growth problems without seriously affecting the salt concentrations in the remainder of the soil. A given amount of salt in a soil provides a higher salt concentration in soil water if the amount of water is small. Soluble salts also interfere with the uptake of water by plants. For these reasons, plant growth is most affected by soluble salts in periods of low moisture supply (drought periods).

Soluble salts can be measured readily in the laboratory by measuring the electrical conductivity of a soil-water slurry. The higher the concentration of water-soluble salts, the higher the conductivity. Table 2–17, *Soil Conductivity Reading Interpretation*, on page 22, provides an interpretation of soil conductivity reading as read in Ontario field soils in a 2:1 water:soil paste, the procedure used by the OMAFRA-accredited soil testing program.

For greenhouse soils, the OMAFRA-accredited soil test uses a larger soil sample and measures conductivity on a saturation extract. For greenhouse crops using this method, conductivity readings up to 3.5 millisiemens/cm are acceptable.

TABLE 2–17.
Soil Conductivity
Reading Interpretation

Conductivity "salt" reading millisiemens/cm	Rating	Plant Response
0–0.25	LOW	Suitable for most plants if recommended amounts of fertilizer are used.
0.26–0.45	MEDIUM	Suitable for most plants if recommended amounts of fertilizer are used.
0.46–0.70	HIGH	May reduce emergence and cause slight-to-severe damage to salt-sensitive plants.
0.71–1.00	EXCESSIVE	May prevent emergence and cause slight-to-severe damage to most plants.
1.00	EXCESSIVE	Expected to cause severe damage to most plants.

Toxicity of Fertilizer Materials

All fertilizer salts are toxic to germinating seeds and to plant roots if applied in sufficient concentration near the seed. Fertilizers vary in toxicity per unit of plant nutrient due to:

- differences in the amount of salts contained in the fertilizer per unit of plant nutrient
- differences in solubility of the salts in the soil
- the high toxicity of a few specific materials or elements (for example, ammonia and boron)

Nitrogen Fertilizers

Ammonium nitrate, monoammonium phosphate and ammonium sulphate are similar in toxicity and much safer than anhydrous ammonia, aqua ammonia or urea. Diammonium phosphate is more toxic than monoammonium phosphate but less toxic than urea. More care should be taken, particularly with sensitive seeds and on coarse-textured soil (sand and sandy loam), than is required with ammonium nitrate or monoammonium phosphate.

Because anhydrous ammonia and aqua ammonia are extremely toxic fertilizers, they should not be placed near seeds. It is preferable to make preplant applications crossways (perpendicular) to the direction in which the crop will be planted.

Urea is toxic when banded with or near the seed but is safe when broadcast at rates normally used. Fertilizers containing more than half as much nitrogen as phosphate frequently contain urea.

Phosphate Fertilizers

Phosphate fertilizers are usually low in toxicity because a large portion of the phosphate is precipitated in the soil before it can reach the plant roots. The concentration of phosphorus in soil solution at any one time is very low. No limit is normally set for the safe rate at which phosphates may be applied with, or near, the seed of field-grown crops.

Diammonium phosphate is more toxic than other phosphate fertilizers (see the section *Nitrogen Fertilizers*, left).

Potash Fertilizers

Muriate of potash (KCl) is the most common source of potassium in fertilizers. It is less toxic per unit of plant nutrients than most nitrogen fertilizers.

Sulphate of potash (K_2SO_4) is less toxic than muriate of potash.

Sulphate of potash-magnesia has approximately the same toxicity per unit of potassium as muriate of potash.

Potassium nitrate is one of the safer sources of potassium.

Fertilizers Containing Micronutrients

Fertilizers containing micronutrients (boron, copper, iron, manganese or zinc) are more toxic than the same grades without micronutrients, and maximum safe rates should be reduced. Boron is particularly toxic and should not be banded.

Foliar Fertilizers

Micronutrients can be supplied to the crop through foliar fertilization, particularly in instances where a deficiency is due to a tie-up of these nutrients in the soil (i.e., manganese). Quantities of nutrient that can be applied this way are limited because of the danger of burning the leaves. Care must be taken when combining nutrients that the resulting solution is not too concentrated. Check pesticide labels before mixing foliar nutrients with any pesticide spray.

Managing Soil Organic Matter

Soil organic matter helps to maintain soil structure, enhances soil moisture-holding capacity, increases the soil's ability to hold nutrients and improves drainage. Maintaining adequate soil organic matter levels can help to maintain crop yields, particularly in years of adverse weather.

Increasing soil organic matter is a slow process, since only a small part of the organic matter added to the soil ends up as stable humus. It is therefore important to keep as much organic matter in the soil as possible by reducing soil erosion and eliminating unnecessary tillage passes. Organic matter additions will also, over time, increase the total soil organic matter. These may be in the form of livestock manures, biosolids, forage crops or cover crops. Manure and biosolids are discussed in a previous section. Rotation plays a key role in maintaining soil organic matter. Try to rotate row crops over a period of 3–4 years with other crops that leave more residue. Sometimes this is not realistic for a variety of reasons. Then it is very important to take every opportunity to use green manure and cover crops to build and protect the soil.

Cover Crops

Cover crops play a major role in Ontario by providing ground cover to reduce erosion and adding organic matter to improve the soil. Following is information on some of the more commonly used cover crops. See also Table 2–18, *Characteristics of Cover Crops Grown in Ontario*, on page 24.

Grasses

Grasses have fine, fibrous root systems that are well suited to holding soil in place and improving soil structure. Suitable grass species for cover crops are fast growing and relatively easy to kill, either chemically, mechanically or by winter weather. Grasses do not fix any nitrogen out of the atmosphere, but they can accumulate large quantities from the soil.

Ryegrass (Annual, Italian or Perennial)

Direct seed in spring or from August to mid-September, or seed with a nurse crop in spring. It has also been broadcast into corn in late June–early July with some success. Annual ryegrass gives the most top growth in the seeding year, often heading 6–8 weeks after seeding. Italian ryegrass (a biennial) does not head in the seeding year, so top growth is considerably less. However, it has the largest, densest root system of the three types. Annual and Italian ryegrasses usually suffer considerable winterkill, but part of the stand may survive. Perennial ryegrass normally survives the winter.

Cautions: Establishment and growth of ryegrasses can be poor during very hot, dry weather. It can be difficult to kill overwintering ryegrass with only cultivation or discing. The nitrogen tied up in ryegrass releases more slowly than from many other cover crops. Thus corn after ryegrass often requires an extra 20–30 kg/ha of nitrogen.

Spring Cereals

Spring cereals are usually seeded for plough-down. Stands seeded from mid-August to mid-September will have 20–40 cm of growth by freeze-up. The stand is generally killed by late hard frosts.

Volunteer spring cereals are sometimes left to grow until freeze-up as a cover crop. Stands may not be very uniform. There may be up to 70 cm of growth by freeze-up, resulting in a heavy mat that keeps the soil wet the following spring. On erosion-prone knolls, spring cereals often have little growth and have been observed to "blow off" by spring, possibly opening the whole field to more erosion.

Cautions: Early seeding may result in considerable growth by freeze-up. If left unploughed in the fall, the mat of dead residue will slow soil drying and warming in the spring, which can cause problems in early seeded crops.

Sorghum Sudan

Sorghum sudan is an excellent choice for growing as a green manure crop for soil improvement. The root growth is extensive and the top growth lush. A preplant herbicide treatment is recommended for crop establishment. Plant after all threat of frost is past in mid-June. The crop will benefit from the warm temperatures of early to mid-summer. Approximately 50 kg/ha of N will help the crop achieve maximum top growth.

Cautions: Sorghum sudan should be mowed before it reaches a height of 1 metre to encourage tillering and ensure that stalks are not woody and will break down readily.

Winter Rye

Winter rye is seeded from September into mid-October, often following vegetable crops. It grows until

TABLE 2–18.
Characteristics of Cover Crops Grown in Ontario

Species	Normal Seeding Time	Seeding Rate kg/ha	Nitrogen Fixed	Overwintering Characteristics	Potential Weed Problem From Volunteer Seed	Supports Nematodes [1]	
						Lesion	Root-Knot
Grasses							
ryegrass	April–May or August–early September	12–18	no[2]	annual, Italian partially survive; perennial overwinters	no	–	–
spring cereals	Mid-August–September	100–125	no	killed by heavy frost	no	+	–
sorghum sudan	June–August	50	no	killed by frost	no	0	–
winter wheat	September–October	100–130	no	overwinters very well	no	+	
winter rye	September–October	100–125	no	overwinters very well	no	+[3]	–
Legumes							
hairy vetch	August	20–30	yes	overwinters	no	++	+
red clover	March–April	8–10	yes	overwinters	no	++	+++
sweet clover	March–April	8–10	yes	overwinters	no	–	–
Non-Legume Broadleaves							
buckwheat	June through August	50–60	no	killed by first frost	yes	+++	0
oilseed radish	Mid-August–early September	10–14	no[2]	killed by heavy frost	yes	0	0

Nematode Rating Codes: – = poor or non-host + = ability to host 0 = some cultivars are non-hosts

[1] Varietal differences in cover crop species may affect nematode reaction.

[2] Oilseed radish and ryegrass do not fix nitrogen from the air but are strong accumulators of nitrogen from soil and manure applications.

[3] Rye: whole season rating would be higher (+++)

freeze-up, then commences growth again in late March–early April (slightly earlier than winter wheat). Growth rate is very rapid during May. The stand is generally killed in late April or early May by tillage or herbicide use.

Winter rye can be seeded later than any other crop and still survive over winter. For good ground cover and erosion protection, it should be seeded at least a month before freeze-up. Winter rye is one of the most consistent, flexible and economical cover crops available.

Cautions: Rye will grow very rapidly under warm temperatures in early spring. Monitor growth to kill it at an appropriate time. It can deplete soil moisture, and incorporation can be difficult if it is allowed to grow too tall.

Winter Wheat

Winter wheat can be seeded in late August through October. It can be seeded outside this time but, similar to spring cereals, weather conditions may reduce top growth. Wheat will survive overwinter and begin growing in April. The stand can be killed through tillage or herbicide application. The plant shuts down earlier in the fall and begins to grow later in the spring than rye.

Cautions: Generally it does not provide the same amount of green material to return to the soil or the level of weed competition that rye provides.

Legumes

Legume cover crops can fix nitrogen from the air, supplying nitrogen to the succeeding crop as well as protecting the soil from erosion and adding organic matter. The amount of nitrogen fixed varies between species, although, generally, more top growth equals more nitrogen fixed. Some legume species have aggressive tap roots that can break up subsoil compaction, but this requires more than one year's growth to happen.

Nitrogen release from legumes can be inconsistent. This must be accounted for when calculating your fertilizer needs. Excess nitrogen release late in the season could lead to excess vegetative growth or split set in tomatoes.

Hairy Vetch

To provide good ground cover over the winter, hairy vetch must be seeded by mid-August. It grows slowly until freeze-up and establishes a very vigorous, fibrous root with moderate top growth. Hairy vetch may also be drilled into winter wheat when the wheat is about 20 cm tall. Seeding at this later stage prevents the hairy vetch from causing a problem with wheat harvest but results in much more vetch growth by freeze-up than does an August seeding.

The vines resume growth early in the spring (similar time to winter wheat) and may reach 150 cm in length if left to maturity. Plough-down stands are usually killed in the spring by tillage or herbicide application. Vetch's fibrous root system improves soil structure, and large amounts of fresh organic matter are added to the soil.

Cautions: Competition from volunteer cereals can lead to poor stands of hairy vetch. On droughty soils, hairy vetch left alive until early May may deplete soil moisture. Roundup is not effective in killing hairy vetch; 2,4-D, MCPA, Banvel or their mixtures should be used. If hormone-sensitive crops are following, apply hormone sprays in the fall to avoid injury.

Red Clover

Red clover is commonly broadcast into winter wheat in March or early April or seeded with spring cereals. Early seeding gives best stands. Double-cut red clover produces considerably more top growth than single-cut (60 cm versus 25 cm, respectively). For plough-down, common seed produces equal results to pedigreed seed, although it may contain more weed seeds.

Major growth takes place from grain harvest until a heavy frost. Red clover can be killed in the fall or the spring by tillage or herbicide application. Unless herbicides are also applied, chisel ploughing will not kill the stand completely.

Red clover plough-down improves soil structure and adds large amounts of fresh organic matter. Nitrogen is fixed and released slowly to the following crop. It gives excellent erosion protection when left unploughed until spring or killed in the fall with a herbicide.

Cautions: Roundup alone is often not effective in killing red clover. Consider 2,4-D, MCPA, Banvel or mixtures. If hormone-sensitive crops are following, apply hormone sprays in the fall to avoid injury.

Sweet Clover

Sweet clover is most commonly seeded into winter wheat in March or early April or seeded with spring cereals. Either the yellow- or white-blossom type may be used. The white-blossom type produces somewhat taller top growth. Major growth takes place after the grain is harvested until heavy frost. Top growth will usually be 30–40 cm tall, but not dense. A strong taproot is produced, often 30 cm long and 1 cm across at the crown. If allowed to grow the following spring, sweet clover will flower in July at a height of about 180 cm, set seed and die. Plough-down stands may be killed in the fall or the following spring by tillage or with herbicides.

Cautions: Sweet clover is very sensitive to many herbicides and will not tolerate any phenoxy herbicides, including 2,4-D.

Non-Legume Broadleaves

These broadleaf crops cannot fix nitrogen out of the air but may absorb large quantities from the soil. Neither of these crops is winter-hardy, so additional control measures are not normally required, but they should not be allowed to go to seed, as the volunteer seed can become a significant weed problem.

Buckwheat

As a cover crop, buckwheat is most commonly seeded in late June–early August. It grows very rapidly, reaching the flower stage and a height of 45–75 cm in about 6 weeks. It has a relatively small fibrous root system and is completely killed by the first frost.

Buckwheat provides rapid soil cover, gives good erosion protection during the growing season, smothers annual weeds and suppresses perennial ones. Moderate amounts of fresh organic matter are returned to the soil. Buckwheat does not fix nitrogen.

Cautions: Late summer seedings may be killed by an early frost before providing significant growth.

Oilseed Radish

Oilseed radish is commonly seeded in August or very early September. It is unaffected by early frosts and can grow to a height of 50–90 cm and bloom in October. The plant has a thick but short taproot, varying between carrot- and turnip-shaped. It is killed by severe frosts in late November or December. It gives a reasonably rapid soil cover and excellent erosion protection over winter and returns moderate amounts of organic matter to the soil. For good growth, this crop must have a large amount of available nitrogen, either from a recent manure application or from nitrogen left from a previous crop.

Cautions: Growth will be poor if soil nitrogen levels are low.

OMAFRA publication 611, *Soil Fertility Handbook*, is an excellent source for more information on a variety of soil fertility topics.

3. Basic Requirements of Ginseng Production

Introduction

Ginseng is a member of the *Araliaceae* family of plants. Members of this family in Ontario are all forest dwelling. Common members of the *Araliaceae* family in Ontario are *Panax trifolius*, dwarf ginseng; *Aralia nudicaulis*, wild sarsaparilla and *Aralia racemosa*, spikenard. Ginseng can be found in the wild but it is rare.

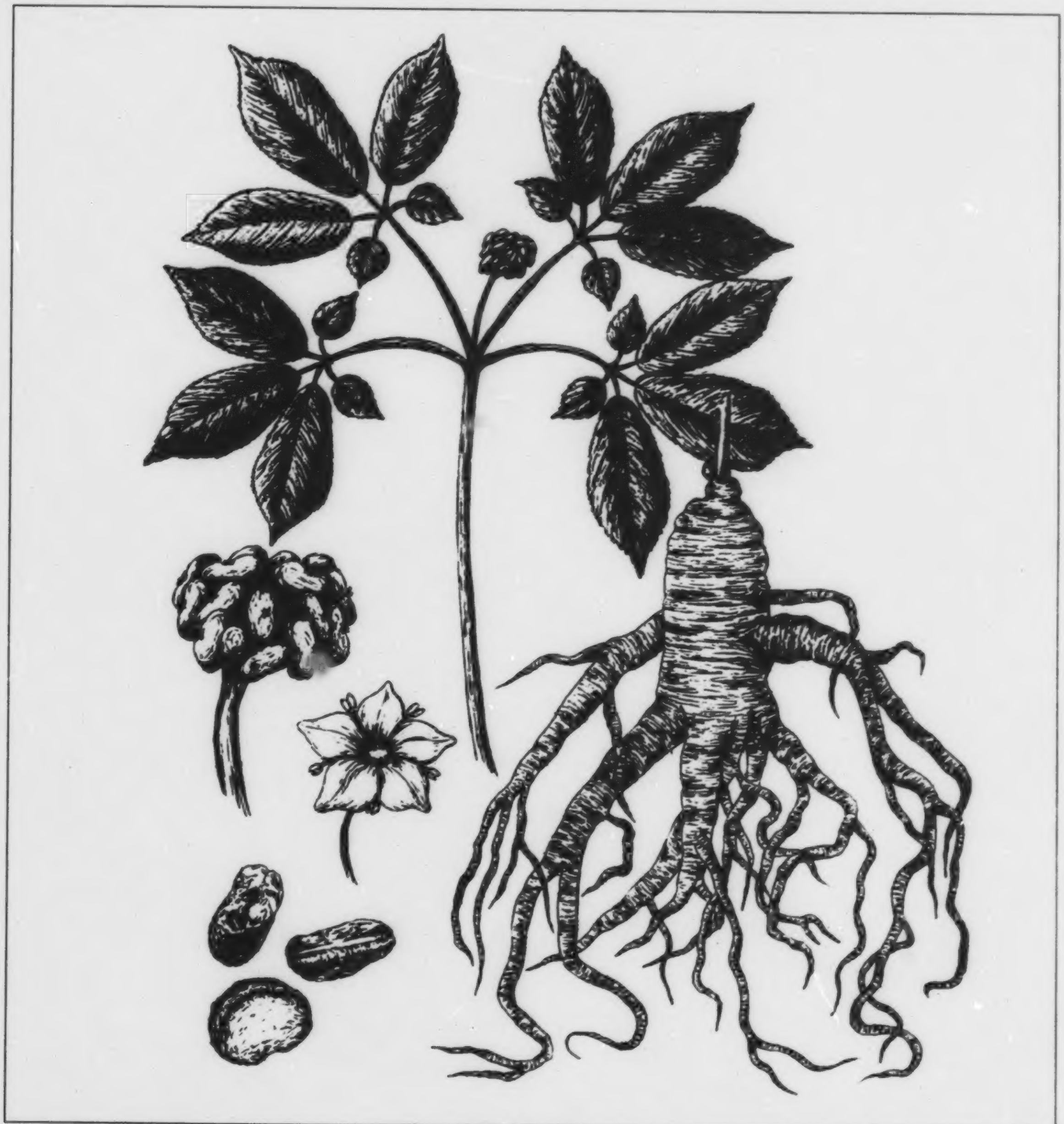


FIGURE 3–1.
North American Ginseng, *Panax quinquefolius:* Roots, Leaves, Seed Head, Flower, Seeds.

Site Selection

Ginseng is a native plant of northeastern North American hardwood forests. Successful field cultivation of ginseng depends on mimicking the environmental conditions of the plant's natural home on the forest floor. The basic requirements of site selection are good drainage, moderate organic matter, soil textures ranging from silt loam to sandy loam and the availability of sufficient calcium.

Nutritional Requirements

There is little information to suggest a nutrient regime for ginseng production in Ontario. The general consensus among ginseng growing areas in North America is that this plant has a low nitrogen requirement. Research has indicated that ginseng uses less than 56 kg/ha (50 lb actual N per acre). The upper limits of nitrogen use have not been established.

Research has shown that calcium is essential both to the growth of the ginseng plant and the health of the root. Most of the soil in the ginseng-growing areas of Ontario have moderate levels of calcium. Soil calcium can be made more available to plants by adjusting the soil pH. When pH is adjusted with the addition of lime (see Table 2–2, *Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH*, on page 14), calcium may also be added.

Initial adjustments in soil nutrition should be made in the preplant year.

pH

Ginseng is found in the wild in soils ranging from pH 5–pH 7. Adjustment of pH is sometimes necessary for field cultivation. pH is commonly adjusted to between 6.0 and 6.5 for new gardens. This pH range allows the best uptake of soil nutrients. If the pH is too low, the plants will be stressed and will be more susceptible to root disease and sometimes foliar disease.

Organic Matter

The organic matter content of hardwood forest soils where ginseng is found ranges from 2%–7%. Soil organic matter content cannot easily be adjusted. Well-composted manure can be added in the preplant year to improve soil tilth. Manure should be added at least 4–6 weeks prior to fumigation and worked in sufficiently to break apart any clumps. Growers traditionally add 20–100 tonnes of manure per ha (10–50 tons of manure per acre). See the section *Manure* on page 18. Ploughdown cover crops are also used to improve soil tilth.

Soil Type

Several types of soil are suitable for ginseng production if the basic requirements of site selection are met. Soil type may also affect root shape. Very sandy soils with low organic matter tend to produce long, pencilly roots. Some markets value this type of root. Other markets require a stubbier "bullet"-shaped root. Soils with gravel or stones will allow water to percolate too quickly and may be prone to temperature fluctuations. Any soil where ginseng is grown must have good drainage. Poorly drained areas of a field should not be planted to ginseng. Subsoil drainage is important. If the soil becomes saturated, root disease may develop. The layer of mulch on top of the beds slows the loss of soil moisture. If subsoil drainage is not sufficient, soil in the beds will remain near capacity and encourage the development of *Phytophthora.*

Water Management

Water management is one of the keys to maintaining garden health. Ginseng will not tolerate poor drainage. Managing excess water in a ginseng garden can be a challenge.

Grading the Garden

Grading a garden before planting is always the best option. When laying out a garden, beds should be designed so that water flows freely from them and out of the garden. This can be done by digging a perimeter trench that is slightly lower than the ends of the garden trenches. Such a perimeter trench can drain into a collection pool or ditch (see PLATE 1 on page 73).

Topographical Assessment

Before planting a ginseng garden, the field should be assessed for natural water flow. In areas where water tends to flow during the early spring and after periods of rainfall, a grassed waterway can be maintained to assist water movement. Gardens that are planted over an entire field without regard for these waterways invariably have areas of *Phytophthora* infections where the water flows on a regular basis (see PLATE 2 on page 73). Movement of machinery through these areas will drag disease throughout the entire garden.

Dealing With Excess Water

Collection pools can be dug to contain water runoff from ginseng gardens. Such a pool should be in a low area and be deep enough to hold water from runoff after heavy rains. When water stands in a trench, it also saturates the adjacent bed. Ginseng roots can reach well down into the soil in the beds and root tips adjacent to a flooded trench will be in danger of infection by *Phytophthora*. When the water subsides, the trench will be "greasy," and soil-borne pathogens can be spread throughout the garden on machinery and boots.

Wet areas in a garden can be hot spots of phytophthora root rot. If there are areas of a garden where water tends to pool in the trenches (see PLATE 3 on page 73) and stand for periods of time, wood chips or other absorbent material (such as a layer of thick straw) should be added to the trenches to prevent splashing. Splashing from wet trenches in diseased areas is a leading cause of foliar phytophthora blight.

Dealing With Soil Compaction

Beds in a ginseng garden are formed along and between rows of posts that support the shade material. Application of fertilizer and pest control products requires repeated driving on the same trenches because this equipment must fit between the post rows. The extensive maintenance required in ginseng gardens often leads to compaction in these trenches. Compaction in the trenches can be alleviated to some extent by subsoiling the trench. This is better done before heavy rains.

Rusty Root

A garden that becomes flooded is susceptible to rusty root. Rusty root can be a result of the exposure of ginseng roots to adverse environmental conditions in the soil. Symptoms can be similar to *Rhizoctonia* infection and to some types of *Cylindrocarpon* infection. Low-temperature injury may also result in rusty root symptoms. Damage to the root can range from superficial scabs to deep scarring. Losses to rusty root in Ontario range from 10%–30% and occasionally higher. Refer to the section *Rusty Root* on page 58 for a description of the symptoms of rusty root in ginseng.

Initial Steps in Ginseng Production

Weed Management/Cover Cropping

Any field considered for the future planting of ginseng should have 1 to 3 years of preparation before seeding. The most effective means of controlling weeds in ginseng is the handling of that field before seeding. See the section *Weeds* on page 42 for methods of dealing with weeds in ginseng and Table 7–3, *Weed Control in Ginseng*, on page 62, for weed control recommendations.

Fumigation

In the summer immediately before seeding, the soil should be fumigated. Fumigation is best done 4–6 weeks prior to seeding. If undecomposed organic matter is present in the soil, it may interfere with the fumigation process. Cover crops and manure should be well worked into the soil 2–4 weeks before fumigation.

Fumigation recommendations can be found in Table 7–1, *Preplant Fumigation in Ginseng*, on page 61. Higher rates are applied to ensure control of root disease pathogens. *Pythium* is present in most soils in Ontario, and fumigation is usually effective in reducing the population of this fungus. *Rhizoctonia* can be controlled to some extent by fumigation. Fumigation does not control all pathogens completely. The effectiveness of fumigation depends on soil temperature and moisture and on how well the land has been worked before fumigation. Even the best attempts at fumigation can be overturned by bringing unfumigated soil into the garden when beds are formed. Care should be taken to prevent this.

Populations of soil microorganisms may remain low for several months after fumigation. After that time, recolonization occurs. In a ginseng garden, recolonization by pathogens depends on sanitation and the protection of the garden against blowing sand and soil and the movement of surface water. Pathogens can enter a new garden on machinery, on animals, on people working in the garden, in unfumigated soil and in surface water runoff. Straw is not usually a source of ginseng pathogens.

Bed Formation and Seeding

Once the field has been adequately prepared, the direction of the beds should be determined (see PLATE 4 and PLATE 5 on page 73). Two considerations should be made:

1. Beds should be formed so that air movement through the garden is facilitated. This will be deter-

mined by the direction of the prevailing winds. Air should move along the length of the garden.
2. Beds should be laid out so that surface water drains effectively out of the garden.

Before ginseng is seeded, sink posts into the ground to allow for the erection of a shade structure (see the section *Managing Shade Requirements* on page 30). After the posts are set, the beds are formed. Occasionally, growers prefer to form the beds before sinking posts.

Ginseng is seeded with a range of seeding equipment (see PLATE 6 on page 73). Refer to Table 4–1, *Seeding Rate and Equivalent 100% Plant Stand in the Seedling Year*, on page 33, for common seeding rates and corresponding 100% plant stand. Seeding rates commonly vary between 89 and 112 kg/ha (80 and 100 lb/acre). Ginseng can be seeded at any time after mid-summer. Care must be taken not to store stratified seed below 8°C. If stratified seed is chilled before seeding, dormancy may be affected, and the seed may germinate in the second year after planting rather than the first.

Managing Soil Temperature and Moisture

Soil temperature is managed through the application of mulch to the surface of the beds. Once the beds are seeded, it is important to follow with a mulch immediately. If the application of mulch is delayed, the newly planted seeds may dry out and fail to germinate the following spring. The most common mulch used is rye, oat or wheat straw. There is some evidence to suggest that, under certain environmental conditions, rye straw as a mulch has allelopathic properties. Allelopathy in this case refers to the ability of the rye straw to inhibit the germination of ginseng seeds and reduce plant vigour. This will only occur under certain environmental conditions.

Usually 5–10 cm (2–4 in.) of straw is applied to a ginseng bed (see PLATE 7 on page 74). Some growers seed oats as a nurse crop at 2–3 bu/acre when seeding the ginseng. The oats will germinate in the fall, act as an anchor for the straw mulch and die off through the winter. Research has shown that this has no deleterious effect on the ginseng. It has not been shown to enhance plant stand. If rye is used as a mulch, the rye that germinates in the fall will survive through the winter and can become a weed problem in the spring.

Application of mulch preserves soil moisture and moderates soil temperature. The soil temperature below straw mulch usually remains above –5°C, even in a very cold winter. This is a critical temperature in the development of rusty root. If soil temperatures drop below –4°C, roots will be damaged. Research has shown that one-year-old ginseng roots are damaged by temperatures lower than –11°C and 3-year-old roots are damaged at temperatures below –16°C.

The mulch also helps to prevent "heaving" of the roots in the spring. Soil temperatures warm more steadily in the spring without extreme fluctuations under the mulch. Root that heaves out of the soil is usually found on the sides of the beds where the mulch is thinnest. These roots often freeze and thaw and become invaded by weak pathogens such as *Pythium*. Fluctuating temperatures can be more damaging to both roots and seeds than prolonged low temperatures.

Managing Shade Requirements

The erection of a shade structure affects both the garden temperature and the light intensity. Ginseng grows best in 75%–80% shade. This can be obtained by the use of wood lath strips placed at 2.5-cm intervals along a wooden supporting frame or by polypropylene cloth woven to shade specifications. There are three types of shade used in the field cultivation of ginseng:

- low wood shade (see PLATE 8 on page 74), about 1.8–2.5 m (6–8 ft) in height, which requires wooden posts and wood lath strips supported by wooden rails.
- low cloth shade, about 1.8–2.5 m (6–8 ft) in height (see PLATE 9 on page 74), which requires wooden posts and polypropylene shade cloth supported by metal rails.
- high cloth shade, about 3–3.7 m (10–12 ft) in height, which requires metal posts and polypropylene cloth supported by metal rails.

Temperature between the plant canopy and the shade material in a ginseng garden depends on the type of shade erected. Low wood shade and high cloth shade are cooler in summer than low cloth shade. Temperature and humidity under low cloth shade can remain high both day and night unless vents are provided for hot air to rise out of the garden. The use of low cloth shade may result in slightly larger roots. This may be because high temperature conditions are conducive to poor seed set. Refer to the section *Ginseng Flower Development* on page 31 for flower development and seed set in ginseng. In any garden, care should be taken to avoid areas where air circulation is restricted. Gardens situated in protected corners of fields surrounded by woods usually have a higher incidence of both foliar and root disease.

4. Flowering and Seed Set in Ginseng

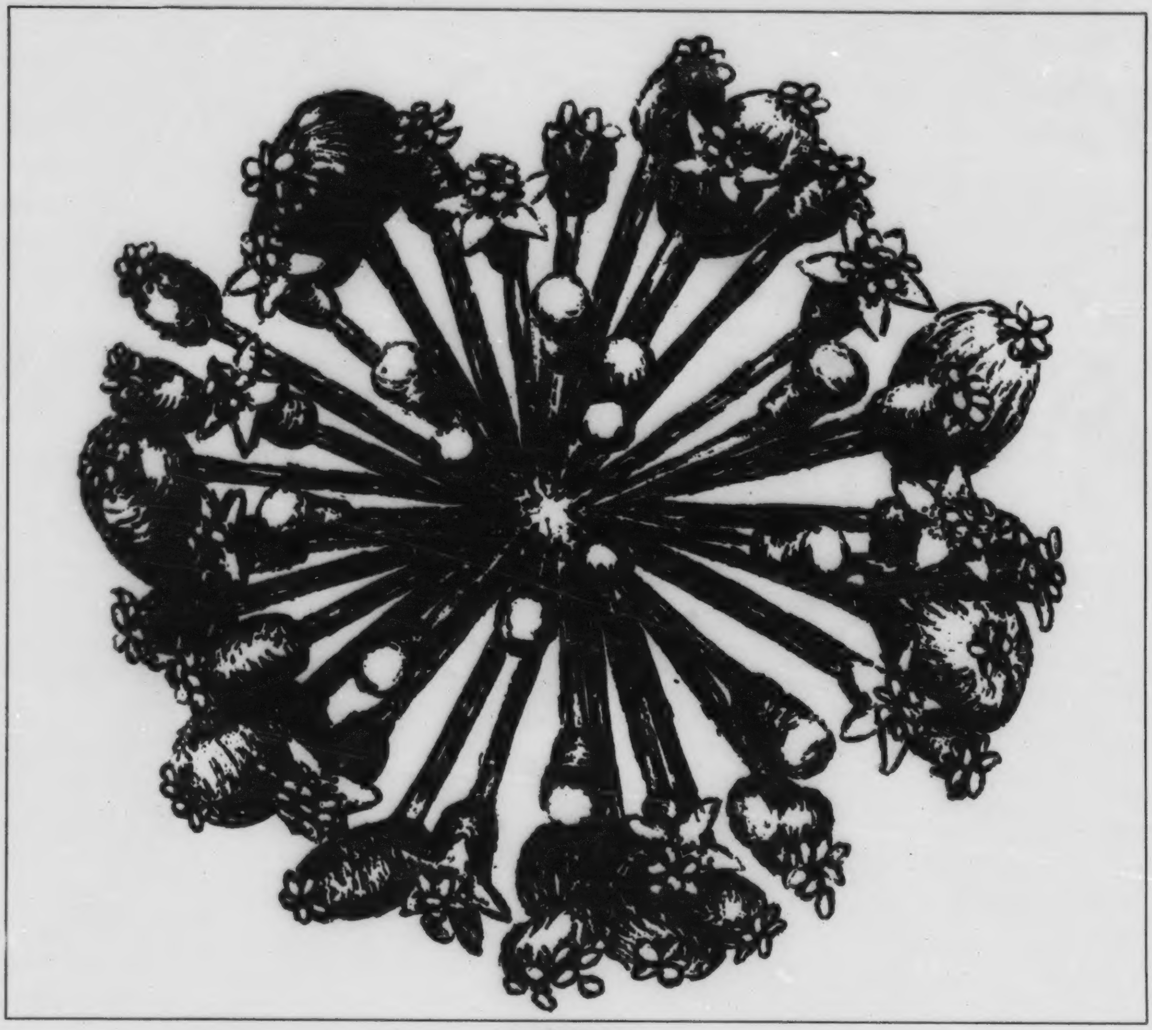


FIGURE 4–1.
Ginseng Seed Head With Concurrent Flower Buds, Flowers and Berries.

Ginseng Flowers

Ginseng Flower Development

Ginseng flowers are borne on an umbel — a flower cluster in which all the flower stalks radiate from the same point. The flower cluster of ginseng arises from the junction, or axil, of the leaves and stem of plants over 2 years old. While some flowering occurs on 2-year-old plants, the majority of flowers are found on plants 3 years and older. Flowering occurs in roughly three flushes and begins at the outside of the umbel and proceeds toward the centre. Ripening of the berries occurs in this same order.

Ginseng flowers over a 6–8-week period beginning in late June. During this period, there will be seed heads that contain flower buds, flowers and berries at the same time. Ginseng flowers are small and inconspicuous. The flowers have 5 greenish-white petals that are 2–3 mm across.

Pollination

Pollination occurs between flowers within a single umbel or between flowers on different plants when pollinators are present. Sweat bees appear to be the primary natural pollinators, but bees are not necessary for fertilization.

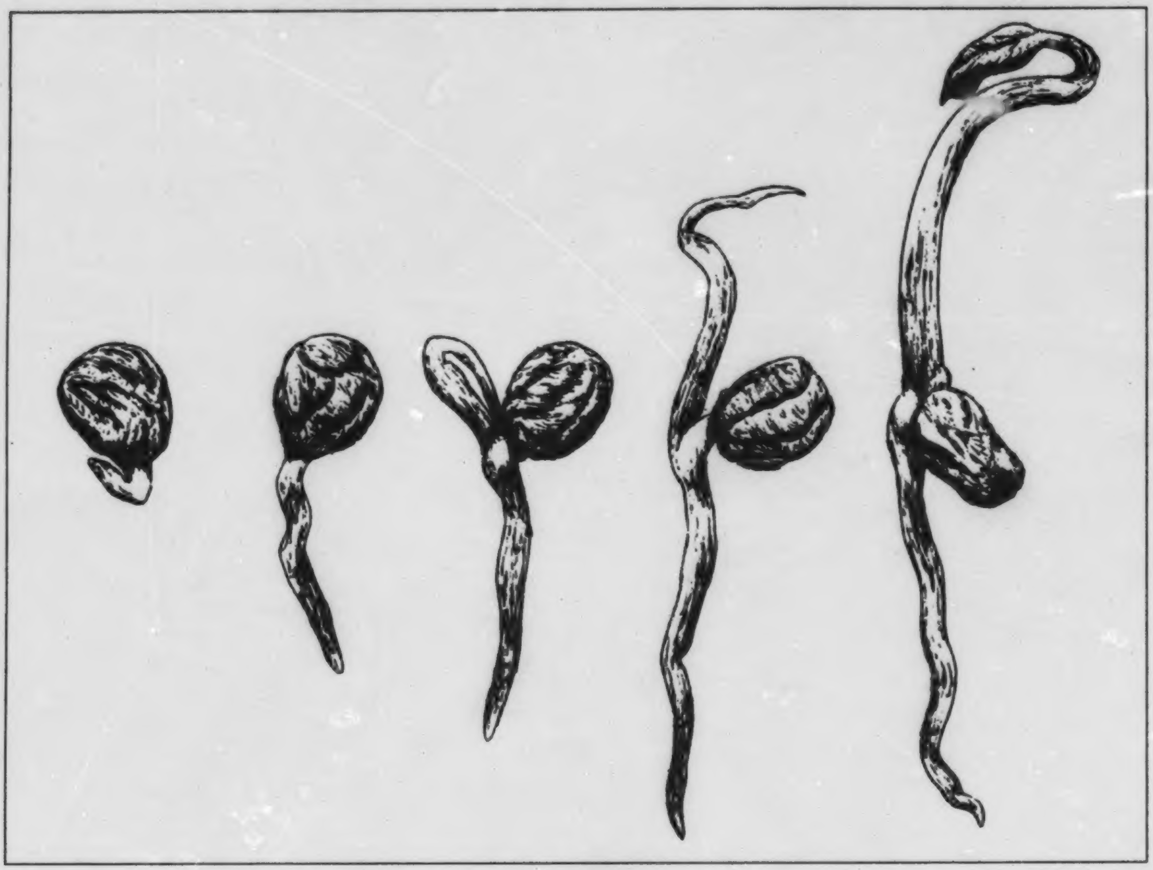


FIGURE 4–2.
Germination of Ginseng Seed

Ginseng Seeds and Berries

Seeds usually set on 80%–90% of flowering plants. Under hot dry conditions, seed set may drop to less than 50%. Weather conditions may cause abortion due to poor pollination or interference with seed development. Conditions causing seed abortion can occur under certain types of shade in hot weather. Low cloth shade can generate daytime highs that, if sustained, may cause the seeds to abort. Raising the shade cloth at intervals to form vents for the hot air to escape can alleviate this.

Four-to-six weeks after flowering begins, ginseng berries are ripe enough to harvest. The berries are bright red when ripe. Each berry commonly contains 2 seeds, although 1 and 3 seeds can occasionally be found. Each umbel may contain 30–40 berries and subsequently 60–80 seeds.

Embryo Development

The Ginseng Embryo

The ginseng embryo is immature at the time of seed harvest (see PLATE 10 on page 74). An after-ripening period of 16–22 months is required for *Panax quinquefolius* seeds before germination. This process is referred to as "stratification." A fluctuating regime of cool-warm-cool temperatures is required for embryo growth.

The length of a normal embryo at harvest is about 0.5 mm. By the time the seed cracks and the young plant emerges, the embryo is 5.0 mm. Part of this growth (about 50%) occurs before seeding and part (the other 50%) after seeding.

One way to check if stratification is proceeding well is to check embryo size. If the embryo is too small just before seeding, it may not germinate the following spring. Embryo size at the time of seeding should be 2–3 mm in length.

Seed Size

A once-over harvest results in seed lots with great variability in size. Seed size affects germination and plant vigour. There is some evidence to suggest that seeds with a diameter of 4.8–5.6 mm (commercial seed grades 12–14) provide the best seeds for good production. Small seeds, under 4.8 mm in diameter, and extra large seeds, over 5.6 mm in diameter, may result in poor emergence and in smaller roots over the life of the garden.

Testing Ginseng Seed

Ginseng seed cannot be adequately tested for germination because of its need for stratification. However, it can be tested for viability. A viability test is a chemical test that indicates whether an embryo is breathing. This is often referred to as a "tetrazolium" test because the tetrazolium dye that is used changes from clear to pink. The test should be done by an experienced individual who can correctly interpret the colour changes during the test.

Planting Ginseng Seeds

Ginseng gardens are seeded mechanically. A variety of equipment is available to growers ranging from simple seeders with a seed-dropping mechanism to high-precision air seeders. In any ginseng growing community, there are usually contract seeders who will do the job on behalf of the grower. Bed-forming and seeding equipment is sometimes combined.

Ginseng Emergence

Ginseng seeds germinate in the spring following planting. Older gardens usually emerge in early to mid-May. Seed germination can be affected by storage temperatures of green seed and sometimes stratified seed before planting. Chilled seed can result in germination a full year after expected. Research attempting to discover a way to shorten the natural dormant period of ginseng has had erratic success, and germination of these seeds ranges from 25%–80%.

Seeding Rate

One kilogram of seed can contain anywhere from 11,000 to 19,000 seeds (5,000–8,500 seeds/lb). This will vary depending on the seed size and moisture content. Ginseng is seeded at the rate of 89–112 kg/ha (80–120 lb/acre). See Table 4–1, *Seeding Rate and Equivalent 100% Plant Stand in the Seedling Year*, right.

Plant Stand

Studies have shown that ginseng self-thins over 3 years to between 80 and 100 plants/m^2 and over 4 years to between 35 and 70 plants/m^2, regardless of the initial plant stand in year one.

TABLE 4–1.
Seeding Rate and Equivalent 100% Plant Stand in the Seedling Year

Seeding rate (lb/acre)	Seeding rate (kg/ha)	Plant stand at 100% germination (no. plants/m^2 of bed)
80	89	161
85	95	172
90	100	182
95	106	193
100	112	204
110	123	225
115	128	236
120	134	247

Research has shown that the more crowded the roots are in the first year of development, the smaller the individual roots will be. Adjusting the seeding rate is an opportunity for growers to address the issue of root shape in the market. High seeding rates may lead to more pencilly roots but it is not the only factor. Pencil roots may also be a factor of soil texture — the less compact the soil, the longer and thinner the roots will be.

Deflowering Ginseng

Effects of Deflowering

Recent research has shown that the size of ginseng roots is affected by early removal of the flower head. The flower head is present from the time of emergence. If it is removed early in its development, the roots will increase in size significantly. Growers must choose between the development of seed and an increase in root weight.

Some 2-year-old plants will have flower buds, but a ginseng garden is usually 3 years old before it has the potential for a seed crop. Most gardens will yield an average seed crop of 336 kg/ha (300 lb/acre) but it can go as high as 560 kg/ha (500 lb/acre). The decision to deflower is made early in the season, and there is a certain risk associated with it. Some growers choose to deflower and leave only a portion of their garden for seed development. In a hot, dry year, especially under low cloth shade, high temperatures may cause abortion of the seeds shortly after fertilization. The practice of deflowering is one of the factors affecting the availability and expense of seed.

Flower Bud Development

When ginseng emerges through the soil in the spring, the flower bud is already present. Flower buds can be seen on plants 2 years old and older. The flower bud is attached at the junction of the stems. As soon as the leaves have unfolded, the flower bud begins to elongate. Eventually it will stand several inches above the leaf canopy. A typical flower head will produce about 40 berries. Berries usually contain 2 seeds.

Root Growth

Once the leaves have unfolded, the plant's energies are concentrated on the reproductive cycle. Root growth is minimal during seed development. Root growth resumes about mid-July when the berries begin to turn red. Deflowering the plant just as the flower bud begins to elongate will redirect the plant's energies to the developing root. Research has shown that deflowering can result in a 25%–30% increase in root weight.

Deciding to Deflower

Table 4–2, *Deflowering Decision Matrix,* right, compares economic returns with and without deflowering. The starting point is an average-yielding 3-year-old garden — 2,800 kg/ha (2,500 lb/acre) — where both seeds and roots will be harvested. What is the economic benefit in deflowering?

Assumptions Before Using the Matrix

A few assumptions need to be made: that the cost of deflowering is the same as picking seed; that average seed yield is 336 kg/ha (300 lb/acre); and average increase in root weight is 560 kg/ha (500 lb/acre).

Interpreting the Deflowering Matrix

Using the matrix in Table 4–2, determine the economic impact on 0.4 ha (1 acre) of ginseng with and without deflowering. Numbers in brackets represent the increase in returns due to increased root weight after deflowering. Numbers without brackets represent the increase in returns if seed is picked and sold as well as roots. It is not always more profitable to deflower. The sale of both root and seed are events that will take place in the future. There is no guarantee that markets for the sale of either will be strong.

TABLE 4–2.
Deflowering Decision Matrix

Seed/Root Values	Roots @ $20/lb	Roots @ $30/lb	Roots @ $40/lb	Roots @ $50/lb
Seed @ $20/lb	($4,000)	($9,000)	($14,000)	($19,000)
Seed @ $30/lb	($1,000)	($6,000)	($11,000)	($16,000)
Seed @ $40/lb	$2,000	($3,000)	($8,000)	($13,000)
Seed @ $50/lb	$5,000	—	($5,000)	($10,000)
Seed @ $60/lb	$8,000	$3,000	($2,000)	($7,000)
Seed @ $70/lb	$11,000	$6,000	$1,000	($4,000)
Seed @ $80/lb	$14,000	$9,000	$4,000	($1,000)
Seed @ $90/lb	$17,000	$12,000	$7,000	$2,000
Seed @ $100/lb	$20,000	$15,000	$10,000	$5,000

For example
If root prices are $20/lb, and seed prices are $20/lb,

- With deflowering, gross sales of roots amount to 3,000 X $20 = $60,000.
- Without deflowering, gross sales of roots and seeds are 2,500 X $20 + 300 X $20 = $56,000.
- The difference is $4,000.
- Because the $4,000 is in brackets in the matrix, it means that deflowering will bring $4,000 more in gross returns than letting seeds develop and selling both seeds and roots.

In other words, the grower can make $4,000 more by deflowering and getting a higher root yield than by selling an average root yield plus seeds.

However, when root prices are $20/lb and seed prices are $40/lb, there is $2,000 more to be made if the flowers are left on, and both seeds and roots are sold, even though root yields will be lower.

5. Harvesting and Handling Ginseng Seeds and Roots

Harvesting and Handling Ginseng Seeds

Harvesting Ginseng Berries

Berries are harvested when they are red (see PLATE 16 on page 75). The red colour indicates that the embryo is ready to undergo temperature stratification. Ginseng berries are harvested by hand. Seeds from fully ripe, red berries give higher emergence rates than seeds from green berries.

Depulping Ginseng Berries

Berries are usually collected into bushel baskets. Before stratification they must be depulped. It takes about 2 kg (4.5 lb) of berries to get .45 kg (1 lb) of seeds. This is sometimes done by placing the berries into burlap bags and letting them sit for several weeks in a cool shed to rot down. The danger in this is the increased chance of seed infection by *Botrytis* and *Alternaria,* which are common moulds that grow on rotting berries.

It is preferable to depulp berries using a mechanical depulper (see PLATE 17 on page 75) within 2 days of picking. Seeds are run through the machine (a modified grater) using water to rinse the pulp away. The pulp-filled water from the depulper can be spread back on the field and incorporated. It should not be added to streams or ponds as it will create a biological oxygen deficit.

Handling Green Seed

Newly harvested depulped seed is called "green seed" (see PLATE 18 on page 75). Green seed should be kept moist and stored between 8°C–10°C. It can be successfully stored as low as 5°C but if the temperature gets lower than this, there is a risk of delayed germination. When germination is delayed, the ginseng seeds emerge not in the seedling-year but in the second-year garden. There is often a small percentage of seeds that do this even when temperature guidelines have been followed.

When green seed is buried for stratification, the soil temperature should be below 15°C. If the soil is too warm when seed is buried, early growth may occur. Soil temperatures in a buried seedbox rarely fall below the freezing point and rarely rise above 20°C (see PLATE 19 on page 76).

Surface Sterilizing Seeds

Green seed should be stored in burlap bags after depulping and prior to stratification. This allows excess water to drain out, but water can be safely added to maintain moisture. Just before being put into the seedbox, seed should be treated with formaldehyde.

- Use 1 part formalin (37% formaldehyde) in 140 parts water.
- Soak seed for 25 minutes.
- Rinse with clean water.
- Surface dry only — do not allow to dry out.
- Mix with sand and place in the seedbox.

Stratifying Ginseng Seeds

Depulped seeds are treated and placed in a seedbox for stratification. The seed is mixed with sand in a 1 part seed to 2 or 3 parts sand by volume (see PLATE 20 on page 76).

Ginseng seed is traditionally stratified by burial below ground. In recent years, more growers are stratifying seeds by storing them above ground in temperature-controlled chambers.

Below-Ground Stratification

- Mix the seed with clean sand in a ratio of 1 part seeds by volume to 2 or 3 parts sand.
- Place the seed-sand mixture into the seedboxes (see PLATE 21 on page 76). Plastic seedboxes with sufficient holes to allow good drainage are ideal; wooden seedboxes carry the risk of transferring disease from year to year. A top layer of about 15–20 cm of sand only or straw is recommended to prevent the drying of seeds near the surface of the box.
- Seedboxes should be buried in the ground so the top layer of seeds is at least 20 cm below the soil surface. Temperature variations below this level are minimal. Ginseng seed is sensitive to temperature

variations during stratification. Excessive cold or heat can delay or induce germination.

- Seedboxes should not be buried in forest soil or in fencerows where there are trees or in areas where forests were recently cleared. Certain crops such as clover can harbour *Cylindrocarpon* without becoming infected themselves. Burial in such an area would carry a higher risk of infection for ginseng seed.

Above-Ground Stratification

Research has shown that ginseng seed can be stratified above ground in a temperature-controlled environment. Above-ground stratification can result in low germination rates if the warm period is too warm or too long. The best germination rate that can be expected using above-ground stratification is 80%. Germination rates can be as low as 20% if temperature or moisture control is erratic.

- Mix green seed with sand as for below-ground stratification (1 part seeds by volume to 2 or 3 parts sand).
- Place seed-sand mixture in plastic boxes. Care must be taken that the boxes do not dry out.
- Hold the seeds at 2°C for 9 months.
- Hold the seeds for $3^1/_2$ months at 15°C. During this time, the embryo will grow from 0.5 mm to approximately 3 mm. The temperature at this time is important and affects the percentage germination. A temperature of 15°C has been shown to be better than 20°C. Remember that ginseng needs cool–warm–cool stratification. The second cool period comes after the seed is placed in the garden beds.

Harvesting Ginseng Roots

Ginseng roots are harvested with a modified potato digger (see PLATE 22 on page 76). Before the root can be harvested, the shade must be removed and the beds scraped clean of plant refuse and straw. After several passes over a garden with a root digger, most of the roots will be on the surface of the soil. Most roots are collected by hand, but harvesting equipment that picks the root up is available.

Ginsenosides and Polysaccharides

Ginsenosides are considered to be the main active components of ginseng, but a number of polysaccharides have also been identified. Two important measures of ginseng root quality are ginsenoside and polysaccharide content. Ginsenosides are a complex mixture of compounds called triterpene saponins and polysaccharides are a mixture of complex sugars. These chemical compounds are affected in both quality and quantity by the production practices employed by growers.

A number of distinguishing ginsenosides have been identified in North American ginseng (*Panax quinquefolius*) through a chemical analysis procedure called high performance liquid chromatography (HPLC). Ginsenosides have been identified in the roots, stem, leaves and flower heads of ginseng but only the roots are used commercially.

The ginsenosides consistently associated with North American ginseng are: Rb1, Rb2, Rc, Rd, Re, Rg1, Ro; the malonyl-ginsenosides are: mRb1, mRb2, mRc, mRd, and gypenoside XVII. One of the distinguishing features of North American ginseng is the absence of the ginsenoside Rf that is present in Asian ginseng.

Root Age

In the commercial production of ginseng, the total ginsenoside concentration in roots increases with plant age over the 4 years during which the ginseng is in the ground. The most pronounced increase (about two-thirds) occurs with the ginsenosides Rb1, mRb1, and Re. Total ginsenoside content increases from about 3% in year 1 to about 8% in year 4. Ginsenoside levels do not increase indefinitely and appear to level off after year 6.

Root age has little effect on the sugar and starch levels of ginseng. Sugar increases in concentration over 4 years from 3% in the first year to 6% in the fourth. During this time, starch concentration shows a corresponding slight decrease from about 55% in the first year to about 49% in the fourth.

Root Size and Shape

No difference in the total ginsenoside content of roots between 2 and 8 gm dry weight has been observed in research trials. The average fresh weight of a ginseng root at 3 years of age is about 20 gm. A root weighing 20 gm fresh will likely weigh 5 gm dried. Roots smaller than 2 gm contain slightly more total ginsenosides than larger roots. Prongs and fibres contain the highest concentrations.

Root shape (pencil or bullet) does not affect either the individual or total ginsenoside concentration.

Harvest Date and Dry Matter Content

Harvest date within a normal range does not affect the dry matter content of ginseng roots. Root moisture and dry matter levels do not change between August and November.

Harvest Date and Starch Content

Starch concentration decreases as harvest date is delayed. The formation of sucrose accounts for about 80% of the starch loss. The other 20% results in the formation of other forms of carbohydrates, possibly polysaccharides. This characteristic increase in sugar concentration has been observed in potato and parsnip and serves to protect the root from freezing.

Harvest Date and Root Colour

Root colour is slightly darker in roots harvested between mid-August and mid-September than in roots harvested later in the fall.

Harvest Date and Ginsenosides

Total ginsenoside levels decline after mid-September and by November may decrease by about 14%. The individual ginsenosides Rb1, Rb2, Rc, Rd, mRd and gypenoside XVII decrease as harvest date is delayed from mid-August until mid-November.

Conditioning Ginseng Roots

Harvested root is stored under cool moist conditions in a refrigerated area for 2–6 weeks to "condition" it (see PLATE 23 on page 76). Conditioned root is then washed (see PLATE 24 on page 76) and placed on drying trays and dried in forced air kilns. Ginseng loses about 75% of its fresh weight during drying.

Advantages of Root Conditioning

The greatest impact of post-harvest low temperature conditioning prior to kiln drying appears to be moisture loss resulting in surface wrinkling as well as darkening of the surface colour. Roots with a shriveled and darkened exterior appearance are often preferred in the marketplace. After 40 days of low temperature storage at 85%–90% relative humidity, roots can lose 27% of their original weight (25.5% moisture and 1.5% dry matter). Significant wrinkling does not occur until 20% moisture has been lost.

Root Conditioning Temperature

Optimum temperature for post-harvest conditioning appears to be between 3°C and 8°C. Past research has shown that roots held at a constant temperature can remain alive at –5°C while temperature that fluctuates between –3°C and 20°C may cause roots to die. This emphasizes the importance of reliable temperature control.

Root Conditioning Temperature and Dry Matter Content

At conditioning temperatures, there is a small dry-matter loss due to respiration of about 1.5% during the first 14–21 days. The dry matter content of fresh root is about 30% but it varies with age. One-year-old roots have a dry matter content of about 24.9% while 4-year-old roots have a dry matter content of about 30.9%.

Root Conditioning Temperature and Starch

The greatest conversion of starch into sucrose occurs between 3°C and 8°C. Extreme conditioning temperatures of –2°C and 13°C decrease the conversion of starch into sucrose. Roots remain alive during the conditioning process. During post-harvest conditioning at 3°C–8°C, roots harvested in August, September and October show a decrease in starch concentration and an increase in sugar concentration during the first 30 days of conditioning. There is no further change in starch or sugar concentrations after 30 days. For roots harvested in November, most of the hydrolysis of starch into sugars has already occurred in the field, and additional low temperature conditioning does not result in any further hydrolysis of starch.

Root Conditioning Temperature and Ginsenosides

Total ginsenoside content is reduced by about 7% when root is conditioned at –2°C. Conditioning temperatures between 3°C and 13°C do not affect the ginsenoside content.

Root Conditioning Temperature and Colour

Root colour is darkened significantly by exposure to –2°C. Slight darkening occurs at 13°C.

Length of Root Conditioning

The length of post-harvest conditioning affects sugar concentration in roots harvested in August, September and October but not in roots harvested in November. Maximum sugar concentration is reached after

30 days of conditioning (except for roots harvested in November). Minimal differences in colour and a slight increase in ginsenoside level (of about 0.6%) occurs within 30 days.

Drying Ginseng Roots

After conditioning, ginseng roots are washed (see PLATE 25 and PLATE 26 on page 77). Care must be taken not to wash the roots too much. Overwashing of ginseng roots results in a white surface colour that can reduce the value of the roots.

Washed roots are placed on trays (see PLATE 27 on page 77) in forced air dryers (see PLATE 28 on page 77) and dried to about 5%–8% moisture. The moisture content of dried roots is slightly higher when roots are not conditioned. Conditioned roots take slightly longer to dry (see PLATE 29 on page 77). The average weight of a 3-year-old dried root is 5 gm. After drying, roots are sorted and packed into cardboard barrels lined with plastic bags. They can be safely stored at cool temperatures up to 2 years.

Drying Temperature and Ginsenosides

Optimum drying temperatures for ginsenoside recovery appear to be 32°C–38°C. The concentration of malonyl ginsenosides decreases if drying temperatures are increased from 38°C–44°C. Total ginsenoside concentration can be reduced by 26% at a drying temperature of 44°C and by 17% at a drying temperature of 38°C compared to freeze-dried root. Only gypenoside XVII increases at the higher temperature.

Drying Temperature and Starch

Starch hydrolysis (the conversion of starch to sugar) occurs at all of the above temperatures during forced air drying of ginseng. More starch is converted to the sugar sucrose when ginseng is dried at 32°C or 38°C than at 44°C. Sucrose is the main sugar found in North American ginseng.

Drying Temperature and Root Colour

Internal root colour darkens as the drying temperature is increased from 32°C to 44°C (see PLATE 30 on page 77). At 44°C, the colour of ground root is darkened to the point of significant reduction in value (see PLATE 31 on page 78). Optimum drying temperature is 38°C.

6. Diseases and Pests

Nematodes

Root-lesion and root-knot nematodes may affect yield and quality in ginseng.

The root-lesion nematode is common in Ontario and has a wide host range. It is frequently found in ginseng-growing areas. Ginseng roots in the seedling year are especially vulnerable to damage from root lesion nematodes. No thresholds have been established. The small size of seedling roots is a factor in considering the number of nematodes present. Scarring on small roots that results from nematode feeding may lead to rust and the formation of prongs. Wounds on the roots from nematode feeding may encourage invasion by *Pythium* and *Fusarium.*

The root-knot nematode has been found in association with ginseng roots. This nematode causes galls to form on the roots, making them unmarketable (see PLATE 38 on page 79). For nematode diagnosis, follow the procedures outlined in Appendix B, *Diagnostic Service,* on page 66.

Preplant fumigation is recommended for most ginseng soils. Fumigation may also help control certain soil-borne diseases such as *Pythium* and *Rhizoctonia,* which affect ginseng quality and yield.

In Ontario, most soil fumigation is done by custom operators. Recommended rates are usually shown as a range (e.g., 225–450 L/ha) and may be broadcast or banded. For disease control, use concentrations near the upper limit. Always follow the manufacturer's directions about rate and methods of use carefully.

Clods of soil and undecomposed organic matter will interfere with the dissipation of fumigants. Allow 4–6 weeks for ploughed-down organic matter to decompose before fumigating. Most fumigants work best at soil temperatures between 10°C and 24°C at 15 cm deep.

If the soil is too dry, fumigants will dissipate too rapidly. In wet soil, fumigants will not be able to dissipate properly and may cause plant damage. Follow the manufacturer's instructions about appropriate soil moisture levels and the length of time the soil is to be "sealed."

Prior to seedbed formation, till the soil thoroughly to aerate and ensure that all fumigant odour has dissipated. Two weeks of aeration with shallow discing should allow trapped vapours to escape.

When preparing seedbeds for ginseng, make sure no unfumigated soil is brought up onto the beds. Unfumigated soil will introduce nematodes and soil-borne disease organisms into the seedbed and could increase the incidence of damping-off and diseases associated with the presence of *Rhizoctonia.*

Refer to Table 7–1, *Preplant Fumigation in Ginseng,* on page 61, for recommendations pertaining to fumigation for ginseng gardens.

Insects

(See Table 7–2, *Insect Control in Ginseng,* on page 61, for insect control recommendations.)

Cutworms

Cutworms are the larvae or young of night-flying moths in the family *Noctuidae.* There are about 20,000 species worldwide. The larvae of most of these species feed on a variety of plants and are serious pests.

The cutworm moths that affect ginseng are attracted to low, wet, grassy areas. As much as 3 bu/acre of kernels of grain can be found in the straw used to mulch a ginseng garden. The environment created once these kernels have germinated is ideal for cutworm moths. Which species of cutworm will be attracted to a garden will depend on the geographic location. In Ontario, the most common species found in ginseng are the variegated cutworm *Peridroma saucia* (Hbn.), the black cutworm *Agrotis ipsilon* (Hufn.) and the dark-sided cutworm *Euxoa messoria* (Harr.).

Cutworm larvae grow to 3.8–5 cm (1½–2 in.) in length. The body usually appears greasy and varies in colour from grey to brown with darker markings. The most distinguishing feature of cutworm larvae is their habit of curling into a "C" when they are disturbed. It is not necessary to know which species is present in order to initiate effective control measures.

Cutworm damage to seedlings can kill the developing plant (see PLATE 39 on page 79). If cutworms are present in seedling gardens, the tops of emerging seedlings can be completely chewed off. After such damage, roots are easily invaded by weak pathogens such as *Pythium*.

Sometimes the first evidence of cutworms will be the severed leaves laying upside-down on the straw. Some species of cutworms will eat holes in the leaves, some will chew off stems.

In areas where winters are severe, the moths of some species fly in from the south each year. Some species overwinter as eggs, others as small larvae in the soil. The timing of egg laying depends on geographic location. During the growing season, cutworm larvae spend most of their days several centimetres below the soil surface. They emerge in the evening and begin to feed on the crop at hand. This key feature of their behaviour is useful in determining the method of control.

Cultural Control

Avoiding or removing stands of grasses or grains will deter egg laying.

Chemical Control

The most effective control for cutworm larvae is treatment with an insecticide.

Most of the damage from cutworms in ginseng will be on the outer edges of a garden. Often a border treatment is sufficient to get good control. It is important to wait until damage is evident and the presence of cutworms is confirmed before treating.

See Table 7–2, *Insect Control in Ginseng*, on page 61, for chemical control recommendations for cutworms in ginseng in Ontario.

Four-Lined Plant Bug

Poecilocapsus lineatus (Fabricus)

The four-lined plant bug will feed on ginseng of all ages but causes economic damage only on seedlings. It feeds on a wide range of cultivated herbaceous plants and woody ornamentals. The insect is a member of the true bug family and is a relative of the tarnished plant bug or lygus bug.

In the northeastern U.S. and Canada, it lays eggs in the early summer, usually in slits in the canes of woody plants. The eggs do not hatch until the following spring. The nymphs appear beginning in late May, depending on the temperature. Nymphs tend to stay in place on the plants where eggs were laid. Adults are very mobile. They can fly to "new" hosts to feed. Usually they "visit" ginseng gardens, but their feeding can cause serious damage to seedlings. Four-lined plant bug adults are most active in ginseng in late June and throughout July. Peak activity times depend on temperature (see PLATE 40 on page 79).

The forewings of the adult range in colour from bright green to yellow with four distinct black stripes that extend the length of the wings, hence its common name. Adults are about 7 mm in length (see PLATE 41 on page 79). The young nymphs have wing pads instead of wings and brightly coloured markings ranging from red to yellow.

Both adults and nymphs have sharp mouth parts that pierce the ginseng leaf and suck out the leaf contents in a localized area. During the feeding process, all of the chlorophyll is removed and a "window" of upper and lower epidermis remains. During feeding, the insect injects a toxic salivary secretion into the leaf.

The spots that result from this type of feeding vary depending on the host. In ginseng, fresh feeding areas are dark coloured but quickly become white or tan and papery. Spots are about 1–2 mm in diameter. If feeding is intense, the spots will coalesce (grow together). Because chlorophyll is removed during the process of feeding, smaller leaves can be rendered unable to use sunlight to make enough starches and sugars to feed the root (see PLATE 42 on page 79).

Feeding damage to older leaves has less impact. Even considerable feeding will leave most of the leaf surface with the chlorophyll intact. Large leaves would need over 50% damage to affect root growth (see PLATE 43 on page 80).

Cultural Control

It may be possible in some cases to "lure" the bug onto a trap crop thus keeping it out of ginseng gardens. The four-lined plant bug prefers to feed on members of the mint family. Recent research has shown that this preference is a strong enough attraction to keep the insects out of a ginseng garden. Experiments in Ontario have found that planting a single mint plant outside the end of a bay of field-cultivated seedling ginseng will keep the insect out of the ginseng under normal population pressures (see PLATE 44 on page 80). The mint can be invasive but can be easily controlled by planting it into a tile or other barrier that prevents the roots from spreading. The mint can be killed back after the seedling year, because damage to older plants from the four-lined plant bug is usually minimal.

While this research has proved very interesting, it was not tested under high population pressure. The population size of the four-lined plant bug varies from year to year. In addition to normal insect population cycles, insect numbers are affected by weather. Populations are higher in hotter seasons.

Chemical Control

If applied as soon as feeding damage is noticed, insecticides may control the four-lined plant bug, but since the insect is so mobile, it could leave the garden before treatment is effective. Check the insecticide recommendations in Table 7–2, *Insect Control in Ginseng*, on page 61.

Pit Scale

Asterolecanium arabidis (Signoret)

Ginseng can be affected by the pit-making pittosporium scale. This insect can be found in the eastern, north central and Pacific Coast states and in Eastern Canada. It attacks many woody and herbaceous plants. Its favourite hosts are mock orange, privet and green ash. It is also found on members of the *Araliaceae* family, which includes ginseng.

Adult scales are oval in shape and are about 3–4 mm in length. The colour of the insect's shell ranges from white to brown and the dorsal (back) surface is strongly convex (see PLATE 45 on page 80).

Depressions or pits are commonly formed beneath the feeding insect. Once attached to the plant, the insect remains stationary.

The ginseng pit scale attaches to the stem and leaf petioles of the ginseng plant. A toxic substance in the insect's saliva is injected into the plant during feeding, which affects the growth of the stem and petioles. Stems and petioles can become severly twisted as a result of feeding by the pit scale (see PLATE 46 on page 80). Plants affected in this manner will remain well below the leaf canopy and will have reduced ability to feed the roots. If the scale attaches to the flower stalk, the stalk will twist downward, and seed production will be limited.

Damage from the pit scale is seen later in the season. The pit scale is an occasional pest that may be found in gardens adjacent to wooded areas. Culling affected plants should prevent the spread of the insect.

Leaf Roller

Archips purpurana (Clem.), Argyrotaenia velutinana (Wlk.) (red banded leaf roller)

Leaf rollers may attack ginseng from emergence to August. The most common species, *Archips*, is a general forest feeder and can be found on hosts such as blueberries, strawberries, violets, willow, goldenrod and sassafras as well as ginseng. It seldom causes economic damage in ginseng.

Adult *Archips* is a small moth with a wingspan of less than 2.5 cm (1 in.). It lays its eggs on ginseng; the hatching larvae "folds" a leaf around itself (see PLATE 47 on page 80). The larvae will grow to about 2.5 cm (1 in.) in length (see PLATE 48 on page 80).

The leaf roller is most prevalent after late June and is more commonly found in older gardens. The most obvious symptom is the drooping, rolled leaves where the caterpillars hide. The caterpillar chews the leaf petiole on one side until the petiole bends but does not break. This interrupts the flow of sap to the leaf, which becomes slightly wilted but does not die. The caterpillar forages from this shelter and returns after feeding.

Leaf rollers are occasional pests of ginseng and are more likely to occur near wooded areas. Their effect on yield has not been measured.

Mealybugs

Acanthococcus dubius

A. dubius has occasionally been found in ginseng gardens. It is common in the eastern U.S. as far north as Maryland. The species has no particular plant preference and has been reported on over 40 different hosts including a number of trees, bushes, flowers and weeds. It has not been known to overwinter in the northern states and Canada but can arrive as an unwelcome "visitor" on shoes and clothing. Growers who grant tours of their gardens should be aware that their guests might bring pests with them.

Mealybugs are soft-bodied insects that are usually covered with a waxy secretion. *Acanthococcus*, however, may be bare or only lightly covered with wax (see PLATE 49 on page 81).

The egg cases of *A. dubius* are found primarily on the underside of the leaves. They are small, oval-shaped sacs about 1–3 mm in length and covered with a white, waxy secretion (see PLATE 50 on page 81). Each egg case can contain many small, salmon-coloured eggs.

On ginseng, *A. dubius* prefers to feed on the main veins of the leaves. Mealybugs are sucking insects and obtain their nutrients by inserting long mouth parts into the plant and sucking out the plant juices. *A. dubius* secretes a toxin into the leaf as it feeds. This toxin results in distortion of the leaf, especially along the main veins (see PLATE 51 on page 81). Note the difference in the type of damage compared to the pit scale. The scale (see the section *Pit Scale* on page 41) prefers to feed on the stem and petioles.

Stem Borers

There are several stem-boring insects that can attack ginseng. Some of these insects may be locally common in areas where there are numerous preferred host plants. Their presence on ginseng is often a coincidence, but some of them seem to have developed a preference for ginseng.

One insect that can be found boring inside the ginseng stem is the European corn borer. The adult is a small moth. Although corn is the preferred host of the European corn borer, its host range is expanding to include a number of other plant species. As the larvae of these insects eat away at the interior of the stem, the plant wilts, and the top dies.

The only way to control stem-boring insects in ginseng is to remove, entirely, the refuse of the crop after it dies back in the fall. Once removed, the leaf and stem refuse should be burned or buried.

Weeds

Preplant Weed Control

Cultural practices in the preplant year can assist in reducing weed populations.

Early in the season, treat perennial weeds that have grown to a height where they are most vulnerable (15 cm) with a non-selective, non-residual herbicide.

Reduce populations of annual broadleaf weeds and grasses by a series of shallow cultivations. The principle is to prepare a seedbed for the weeds, allow them to germinate and work them under. Repeat this procedure as long as soil moisture permits. Avoid the formation of a dust mulch through excessive cultivation, as this will prevent the weed seeds from germinating.

Introduced Weeds

Weeds can be introduced into ginseng gardens with the mulch material. In every bale of straw mulch applied to a ginseng bed, there are approximately 2–3 bushels of kernels. Using a straw mulch that will not produce winter-hardy seeds or seedlings will help prevent volunteer grains in the spring (see PLATE 52 on page 81). Use clean straw from fields with low weed populations.

Weeds can also enter on the wind. A rye strip set against the prevailing winds around the garden border will stop some weed seeds from blowing into the garden. The rye strip will also help prevent sandblasting.

Refer to Table 7–3, *Weed Control in Ginseng*, on page 62, for weed control recommendations in ginseng in Ontario.

General Pests

Slugs

Slugs are molluscs and are more closely related to clams than to insects. Insecticides will not control slugs.

Slug damage in ginseng consists of destruction of seedlings, removal of or damage to the leaves (see PLATE 53 on page 81) and excavation of the roots.

Slugs are attracted to cool, wet areas and are most active at night. In ginseng, the straw mulch provides an ideal climate. Slugs are more likely to occur where ginseng follows sod, where there is a large amount of crop refuse and in heavy, poorly drained soils.

Certain cultivation practices can minimize slug damage. Organic matter should be worked well into the soil and composted prior to seeding. In established gardens, maintain good drainage by grading the surrounding area for efficient water removal and by subsoiling the trenches each fall.

Barriers of hydrated lime, ashes, coarse sand or diatomaceous earth will act as deterrents to slugs invading the garden from the surrounding areas.

Monitor slug activity by cutting oranges or grapefruit in half and placing them, cut side down, at several spots in the ginseng garden. Inspect the fruit in the evening for the presence of slugs. This will show you if slugs are present but won't indicate the potential for damage. Slugs are also attracted to beer. Small shallow tin plates sunk into the soil to the rim and filled with beer can be good indicators of slug activity.

Slug bait containing metaldehyde should be used only in bait stations. Bait stations are most effective placed about 1 m apart and covered.

Rodents

Mice may damage ginseng by chewing on stems and exposed roots. The mice tunnel beneath the straw mulch and tend to establish runways along the length of the beds. Mice may invade ginseng gardens in the fall if surrounding vegetation is removed.

Refer to Table 7–4, *Rodent Control*, on page 62, for rodent control recommendations in Ontario ginseng.

Disease Control

Sprayer Technology

Except for Aliette, the fungicides used in a ginseng disease control program are protectants. A protectant fungicide forms a protective barrier on the plant that kills or inactivates certain fungi. Protectants are effective as long as they remain on plant surfaces. Repeated rainfall will reduce the amount of fungicide present. The critical amount of rainfall depends on the individual chemical.

TABLE 6–1.
Boom Sprayer Set-Up
Use drop arms between the beds.

Item	Settings
pressure	896 kPa (130 psi)
ground speed	3 km/h (2 mph)
nozzle spacing	30-cm (12-in.) centres
nozzle set-up	D3-45,[1] D6-46 on boom ends

[1] D3-45 will deliver about 966 L/ha (85 gal/acre), D4-45 about 1,477 L/ha (130 gal/acre).

Note: Aliette is a systemic fungicide. Unlike a protectant, Aliette is mobile inside the plant and is most active after uptake. Aliette should be applied at 909 L/ha (80 gal/acre)or less. Do not apply Aliette to runoff. To be effectively taken up by the plant, Aliette should remain on the leaf surface for 1 hour.

Applying fungicides efficiently not only makes the best dollar sense, it also provides the best possible control of diseases. The sprayer parameters listed in Table 6–1, *Boom Sprayer Set-Up,* above, will ensure coverage of the upper and lower leaf surfaces and of the stem and seed head. These are areas where disease most frequently begins.

Always follow the label instructions when applying fungicides. To check the most recent label information, visit the PMRA (Pest Management Regulatory Agency) Web site at http://www.hc-sc.ca/pmra-arla/qcont-e.html and type the name of the chemical in the query box.

Foliar ginseng diseases can cause serious economic loss. Ginseng roots increase in size each year from mid-July through September. A 3-year-old garden can increase in yield by 560 kg/ha (500 lb/acre) during such a growth period. Foliar disease that strikes a garden before mid-July can dramatically reduce this weight gain.

These losses occur as a result of stem canker, loss of photosynthetic surface due to lesions and defoliation caused by the fungi *Alternaria panax* and *Botrytis cinerea.* The initial focus of foliar disease in a garden is usually the stem. If fungi are left unchecked, leaf disease and head blight will follow. Defoliation can occur within 7 days of infection in an untreated garden. Once foliar disease becomes established in a garden, growers are forced into a 7–10-day treatment schedule.

Control of diseases on the stem and in the leaf canopy depends to a large extent on the use of appropriate fungicides and on adequate coverage of the plant surface to be protected. The performance of fungicides depends first and foremost on how effectively the product is deposited at the site of infection. To control fungi that attack the stems, seed heads and leaves, product must be deposited thoroughly on all these parts, including the underside of the leaves. Spray deposition depends on the type of sprayer used and, for boom sprayers, on the type and configuration of nozzles.

Proper selection of sprayer type and water volume will have a large impact on spray coverage throughout all parts of the plant canopy. For a complete discussion of the three sprayers most frequently used in ginseng, visit the Ginseng Index Page of the OMAFRA Web site under the Farm Machinery section of "Factsheets, Infosheets and Publications" at http://www.gov.on.ca/omafra/english/crops/facts/info_000612.html.

The importance of coverage in the control of foliar diseases cannot be understated. It is the first factor that should be considered when protection fails. Frequent sprayer calibration will help to ensure that your sprayer performs at its optimum level.

If coverage is adequate, and the choice of fungicide appropriate, but disease remains uncontrolled, consider the possibility that resistance has developed.

Fungicide Resistance

Causes

Simply stated, fungicide resistance is the ability of a fungus to survive in the presence of normally lethal doses of a fungicide. If the fungus is a pathogen that causes plant disease, then fungicide resistance means that application of that fungicide will not control the disease.

The importance of resistance management cannot be overstated. Very few new fungicides have been registered for use in Canada in recent years. This means that we must carefully use the products that we have.

How does resistance develop? Most fungicides act against fungi by interfering with basic chemical steps of fungal growth and development. Some of the older fungicides interfere with numerous steps or pathways and are effective against a number of different fungi. These are called "broad spectrum" fungicides. Resistance is not likely to be a problem with these fungicides as there are just too many hurdles for a fungus to overcome in order to survive.

Many of the newer fungicides are "narrow spectrum." That is, they affect a limited number (sometimes only one) of the functions that a fungus needs to survive. They may block a reproductive process or the development of cell walls or they may prevent the ability of the fungus to use a food source, etc. Each fungicide is active against only a select group of fungi.

These fungicides tend to be very effective. But this also means that there are a limited number of changes a fungus must go through to overcome the action of the fungicide. Development of resistance should be a serious concern. Too many applications of these fungicides will render them ineffective as control agents.

In the overall population of fungi, there are usually some that can adapt to a fungicide and develop resistance. Frequent use of a narrow spectrum fungicide will kill vulnerable fungi, but the resistant ones will survive. When this happens, the fungicide is no longer effective. Doubling or even quadrupling the dose will not overcome this. Resistant fungi usually have the ability to tolerate ten-to-several thousand times the rate of fungicide.

Once resistance develops, it may take several years for the population of fungi to become susceptible again after the use of the fungicide is stopped. In some cases, susceptibility never returns.

Ultimately this means that we must carefully manage the use of narrow spectrum fungicides.

Prevention

Eight factors are important in effective fungicide use.

Timing

Application must be made in time to protect the plant. Most of the fungicides that we use do not cure disease, they protect the plant from attack and prevent or interfere with the initiation of the disease process. Protection must be in place before the pathogen has the opportunity to penetrate the plant where it is less likely to be affected by the fungicide.

Rate

The label rate is the rate to use — too much will hasten the development of resistant strains, too little will not do the job. Label rates were designed and tested to give optimum performance. Trust them. Do not assume that the rate used to control one fungus will control other fungi.

Coverage

Thorough coverage is essential for good control. This means upper-leaf surface, lower-leaf surface and stem! To be effective, a fungicide must be delivered to the target fungus. High water volumes may be required to situate the fungicide in the soil where soil-borne disease is a concern. Low water volumes may be required when a fungicide must be absorbed by the plant in order to be effective against the target fungus.

Rotation

Do not repeatedly use the same chemical back to back in a control program. The mode of action of fungicides is usually based on the molecular structure of the chemical. Members of a "chemical family" usually have similar structure and therefore similar modes of action. This also means that if resistance develops to one member of a chemical family, other members of that family will also be ineffective.

Seeding Rates

Use all means of lessening the impact of pathogens in your garden. Avoid high plant density. Ginseng self-thins to about 80–100 plants/m^2. High initial seeding rates do not result in higher plant stands after 3 or 4 years. They do, however, put young gardens under stress, and the short distance between roots underground means that fungi have easier access to the next plant. Seeding rates of 89–112 kg/ha (80–100 lbs/acre) are adequate for most gardens.

Water Management

Gardens should be landscaped for effective surface water removal. Surface water can be managed with perimeter trenches and collection ponds. Careful attention should be paid to natural water flow and measures taken to accommodate it. Trenches where water collects should have gravel or wood chips to prevent splashing. Subsoiling the trenches helps drainage and soil compaction.

TABLE 6–2.
Disinfecting Equipment

Sanitizing Compound	Mixing Rate With Water
hypochlorites (bleaches 5.256% active)[1, 2]	1 part bleach to 9 parts water
quaternary ammonium (10% active)	1 part ammonium in 300 parts water
37% formaldehyde (Formalin)[2]	3 parts Formalin in 100 parts water

[1] Corrosive to metal. Residues on machinery may harm plants. Rinse well.

[2] Wear a suitable respirator. Ventilate following treatment. Fumes are toxic to plants and humans.

Fertility Practices

Practices that promote lush canopy development also promote conditions favouring disease. Excessive canopy development makes stem coverage more difficult. Poor stem coverage is the leading factor in the development of *Alternaria* "hot spots" in a garden.

Air Circulation

Plant spacing and garden design should have air circulation in mind. Stagnant air pockets mean areas of prolonged high humidity. This promotes the development of disease, especially within the leaf canopy.

Disinfecting Equipment

Ginseng diseases can be spread via machinery. When moving from garden to garden, work in younger gardens first. After working in diseased gardens, wash all equipment with a high pressure washer to remove soil and plant debris. Disinfectant applied to clean equipment will help prevent the spread of ginseng pathogens.

Diseases can also be spread on boots and clothing. When entering a garden, make sure that the soles of your boots have been cleaned or change to a new pair of plastic "booties."

Diseases of Seed Heads and Flower Heads

The flower and seed heads of ginseng are susceptible to three fungal diseases that can cause economic loss.

Alternaria panax

Alternaria panax can invade the stalk supporting the seed head or the small stalks supporting the individual seeds. Infected stalks shrivel and become tan coloured. Once these stalks shrivel the seed aborts.

Botrytis cinerea

Botrytis cinerea can infect developing berries. In most crops, *Botrytis* enters the flower around the time of petal drop. The exact timing of entry into ginseng berries is not known. Infected berries take on a purple colour and begin to dry out. Eventually these berries abort.

Refer to the sections *Alternaria Diseases of Ginseng* on page 53 and *Botrytis Blight of Ginseng* on page 55 for the symptoms of *Alternaria* and *Botrytis* infections of ginseng.

Powdery Mildew

Powdery mildew can also affect ginseng berries. The powdery mildew fungus causes a late-season disease and may be more severe in some years than others. Developing seed heads become covered with a white "powdery" mass of fungal spores. The disease is superficial but can cause berries to shrivel and may interfere with seed development.

Diseases of Ginseng Seeds

Garden health begins with the planting of healthy seed. The first evidence of potential seed problems can often be found after stratification and before seeding.

Before or during stratification, seed may become infested with bacteria and/or fungi. Some of the infected seed may decay during stratification. Decayed seed has a lower specific gravity (it will be lighter) than healthy seed. Growers can take advantage of this fact and "float" seed to remove those seeds that are decayed. It is not unusual to have up to 15% "floaters." If a seedlot has more than 15% seed that floats, serious consideration should be given to rejecting it. Some of the diseased seed will not float if decay is not advanced enough to affect specific gravity. There are usually as many diseased seeds that remain as there are floaters. If seed is dug early enough, it can be floated more than once.

The fungi that infect seed are *Rhizoctonia* (see PLATE 11 on page 74), *Pythium* (see PLATE 12 on page 74), *Fusarium* and *Cylindrocarpon* (see PLATE 13 on page 75). The presence of *Fusarium*, *Rhizoctonia* or *Cylindrocarpon* can be detected in seed that sinks by cutting the seed in half. Cuts should be made through the pore and along the groove that separates the two halves of the seed coat. If these fungi are present inside the seed, there will be a rusty discolouration. This could be anywhere within the seed and can range from a small spot to extensive discolouration.

When *Cylindrocarpon* or *Fusarium* have infected a seed, it can usually be seen on the exterior of the seed coat. Fruiting bodies called "sporodochia" can be seen without magnification (see PLATE 14 on page 75). They are usually 1 mm or less in diameter and will be white or coloured pink to red. They are rimmed with a row of short "spines." These fruiting bodies contain masses of conidia (spores). If these seeds are not culled from the seedlot, *Cylindrocarpon* and *Fusarium* conidia will be introduced into the new garden in vast numbers.

Seed rotted by *Pythium* usually has a "cheesy" interior.

Botrytis can also infect seeds (perhaps starting as a latent infection) and cause rot in storage. Seed decayed by *Botrytis* will float to the surface when the seeds are immersed in water. *Botrytis* seed infections can begin during depulping when seeds are left too long either to rot the pulp or after mechanical depulping when seeds are left too long before burial.

Seed can also be decayed by bacteria. Bacterial decay of ginseng seed usually causes the interior to liquefy into a milky or sometimes black fluid. When the seed is squeezed, the liquid will ooze out through the micropore (see PLATE 15 on page 75). Seed decayed by bacteria has a sour odour. Healthy ginseng seed should have no odour.

Post-Harvest Diseases and Disorders of Ginseng

Red Root (Varicose Disorder)

Occasionally, ginseng root will develop lengthwise red streaks along the root surface (see PLATE 32 on page 78). These streaks may be numerous enough to give the root an overall red appearance. Close examination of the red streaks reveals that they are distinct (see PLATE 33 on page 78) and occur primarily in the outer layer of the root interior (see PLATE 34 on page 78).

Ginseng roots contain secretory ducts. Under certain environmental conditions, these ducts will become filled with phenolic compounds. As the root dries, these compounds turn red. This seems to be independent of the drying temperature. There has been no research indicating a connection with root nutrition, but water relations early in the life of the plant is a consideration.

Mouldy Root

Sometimes root decay will occur during drying. This happens under very specific circumstances. Sanitation and proper air circulation usually prevent these drying problems. There are two fungi associated with mouldy root in the kiln.

Rhizopus Rot

Rhizopus is a common fungus and can be found on many objects, in the soil and in air currents. It is one of the bread mould fungi that occurs on stale bread. If *Rhizopus* is present in the drying kiln, it may cause a rapid decay of ginseng roots during that period when both temperature and humidity are high. Affected roots will develop grey patches that will remain visible after drying is complete (see PLATE 35 and PLATE 36 on page 78). Affected roots are unmarketable. The source of *Rhizopus* in drying kilns is most often dirty fan blades. Before ginseng is dried, all blades should be checked and cleaned.

Geotrichum Mould

Geotrichum candidum is a soil fungus that can be found in most agricultural soils. It is only a problem on ginseng in faulty kilns. It is very important to ensure good air circulation when drying ginseng. If a kiln has areas where humidity persists, this fungus may develop. *Geotrichum* develops at temperatures around 37°C (see PLATE 37 on page 79). It produces many conidia that are easily dislodged when handled and can cause lung irritation in humans. It has a distinctive dirty-white "fuzzy" appearance and usually a sour odour. If this mould is found in a kiln, respirators should be worn when removing decayed root.

Disease Profiles

Pythium Damping Off of Ginseng
Pythium spp.

The Fungus and Symptoms

Pythium is a soil fungus. It belongs to the same group of fungi as *Phytophthora.* There are structural differences between the two fungi that may be evident under the microscope, but if only mycelium is visible, the two cannot be differentiated. *Pythium* is referred to as a "facultative saprophyte," which essentially means that it can exist in the soil on organic matter and can attack seeds and seedlings (in the case of ginseng) as the opportunity arises. Because it can exist on soil organic matter, it is present in a wide variety of soils from season to season. It does not need ginseng to survive. *Pythium* can be found in most agricultural soils in Ontario.

Pythium is a serious disease of seedlings and germinating seeds. It is frequently involved in damping-off. Damage to young roots can be extensive. Other fungi involved in damping-off are *Fusarium, Rhizoctonia* and sometimes *Alternaria.* A diagnosis of damping-off only relates to the symptoms of disease, not to the causal agent. The fungus associated with the symptoms needs to be positively identified in order to recommend treatment.

When *Pythium* attacks seeds, the seed coat will not rot away, but the interior of the seed will become a curdled, "cheesy," creamy-coloured mass. Eventually, the interior of the seed disappears, and only the seed coat is left. *Fusarium* can be associated with this type of seed decay as well, but when *Fusarium* is the culprit, there are usually "sporodochia" present on the seed surface. Sporodochia are matted areas of mycelium and conidia that look like small white or black dots on the seed coat. With *Fusarium* and *Cylindrocarpon,* there is usually some discolouration in the interior of the seed. *Cylindrocarpon* also produces sporodochia (a "cushion" of conidia) on the seed coat. The colours of the sporodochia can range from cream to salmon to red. Refer to the section *Diseases of Ginseng Seeds* on page 46 for a discussion of seed diseases of ginseng.

Pythium can attack both the developing root and shoot of the seedling, and the seedling can rot before emergence. If it does emerge, the leaves will droop and collapse; this is followed by the collapse and death of the entire seedling.

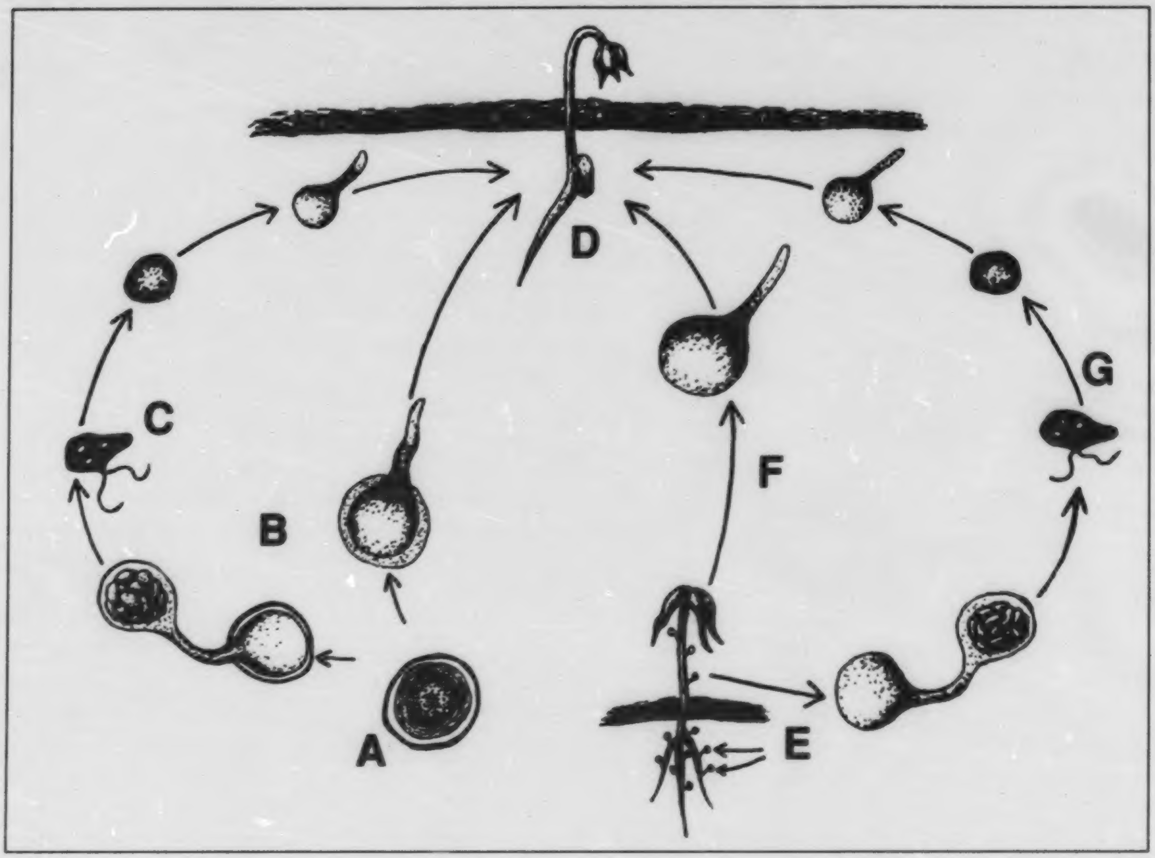


FIGURE 6–1.
Life Cycle of *Pythium* on Ginseng

A. Like *Phytophthora, Pythium* overwinters as oospores.
B. *Pythium* oospores can germinate directly, which they do under relatively warm, moderately wet conditions, and the developing mycelium can infect emerging seedlings. Under cool, wet conditions, the oospores germinate to form sporangia that, like *Phytophthora*, contain many swimming zoospores. *Pythium* sporangia are not released like *Phytophthora* sporangia, and zoospores are therefore only released into the soil water matrix.
C. When zoospores contact plant tissue, usually the developing roots and stems of emerging plants, they invade the tissue and form cysts called encysted zoospores and they can remain in this form until conditions are right to proceed with infection.
D. *Pythium* causes a soft rot of plant tissue. It attacks young or weak tissue.
E. Many sporangia form on decaying plants. These sporangia release zoospores that continue the cycle (G). These sporangia will not be visible with the naked eye. Like oospores, sporangia may germinate directly (F).

A "facultative saprophyte" such as *Pythium* is most often associated with disease in weakened plant tissue. Because emerging seedlings are relatively fragile compared to older roots and shoots, this is the stage most often attacked. Older roots that have been injured mechanically by mice, slugs, nematodes or insects, by heaving after frost or by other fungi, such as *Fusarium*, may also be involved. When *Pythium* is involved in the rot of older roots (see PLATE 54 on page 81), it is almost never alone, and other root-rotting fungi, as well as nematodes, can be found.

If *Pythium* is present in the soil in garden beds, damping-off usually occurs in patches that are roughly circular. If it is introduced on seed from the seedbox, single plants will "go down" wherever *Pythium*-infested seed is present. In heavily seeded gardens, surrounding roots may become infected.

Factors Promoting Disease

Like *Phytophthora*, this fungus has swimming zoospores and is more active under wet conditions. Gardens where the surface water drains slowly or where water pools are more likely to be show signs of damping-off or root decay. *Pythium* infections can occur under drier conditions than *Phytophthora*.

Seedboxes can harbour *Pythium*, and seeds can become infected where surface runoff from older gardens flows over the buried seeds. If ginseng plant refuse is present uphill from a seedbox, contamination is very likely.

Another factor influencing the *Pythium* disease cycle is contamination of the beds with unfumigated soil. Poor fumigation or movement of unfumigated soil will introduce *Pythium* into the new seedbed. Because this fungus is present in virtually all soils in this region, it can be introduced with unfumigated soil from areas below the fumigation zone. After fumigation, the balance of soil microbes is disturbed. Any fungi that are introduced into fumigated soil will have none of the checks and balances exerted by normal soil microflora and microfauna. This allows introduced fungi to grow and attack seeds and seedlings with ease.

Disease Management Practices

Cultural Control

The single most important management practice is the care taken when forming beds. Fumigation should be deep enough to allow bed formation in the fumigated zone. Throughout the ginseng-growing areas of Ontario, unfumigated soil can be assumed to be contaminated with *Pythium*.

Other practices are similar to those used for *Phytophthora* in relation to water management and garden sanitation. Elimination of standing water and facilitation of runoff is essential. Even after good fumigation and proper bed formation, *Pythium* can be introduced on machinery and boots or shoes from older gardens. It is important to work in seedling gardens first and to insure that workers wear plastic booties or decontaminate their boots or shoes.

Soil can blow into gardens and filter through the straw to contaminate beds. While nothing can be done to prevent the wind from blowing, gardens can be somewhat protected by a rye strip that breaks the force of the wind. A metre-wide strip of rye or other fast-growing grain situated against the prevailing winds can act as a barrier to the introduction of *Pythium* on particles of soil. Such strips may need to be managed for cutworm control in the spring. Any good windbreak will suffice, but care should be taken not to stifle the air movement to the point of creating an environment for foliar disease.

Chemical Control

The first line of defense is fumigation. Alternatives to the use of fumigation are being explored through research.

Rhizoctonia Diseases of Ginseng

The Fungus and Symptoms

Rhizoctonia solani is a soil pathogen. Unlike many other fungi, it does not produce spores (except in very specific circumstances). It grows through the soil vegetatively as mycelium (fungal threads). When it encounters susceptible plant tissue, it forms a compact mass of mycelium called an infection cushion and proceeds to penetrate the host. Once inside the host, it grows rapidly and may form small sclerotia (clumps of dark-walled cells) and "runner hyphae" (hyphae are the individual threads that make up the mycelium). Using the energy from its host, the fungus can travel to and infect adjacent roots within several centimetres of the diseased root. As it moves out from its original focal point, circular areas of disease develop in infected gardens (see PLATE 55 on page 82). *Rhizoctonia* is one of the world's most rapidly growing fungi. Under ideal conditions, the circles of dying plants can expand at the rate of approximately 1 metre per month.

Rhizoctonia prefers the upper zone of the soil. It can be especially active between the soil and straw mulch. Infection occurs on the crown or bud and on the stem between the straw and the soil (see PLATE 56 on page 82).

Rhizoctonia infection usually results in a rusty or reddish discolouration of the affected tissue (see PLATE 57 on page 82). *Rhizoctonia* can appear as a dry, corky rot that may or may not penetrate the root tissue deeply. Roots damaged by *Rhizoctonia* are more susceptible to invasion by bacterial rots and saprophytic soil micro-organisms such as nematodes and small insects. While the *Rhizoctonia* itself may be superficial on the root, the secondary invaders may cause increased damage.

Seedlings and second-year roots (see PLATE 58 and PLATE 59 on page 82) are most susceptible. *Rhizoctonia* is part of the damping-off complex (see PLATE 60 on page 82). In the case of seedling damping-off due to *Rhizoctonia*, the entire root usually decays. Seedling stems are also attacked. Stem rot of very young seedlings causes a soft decay, and the plant topples over. Slightly older roots may develop a tan or rusty lesion

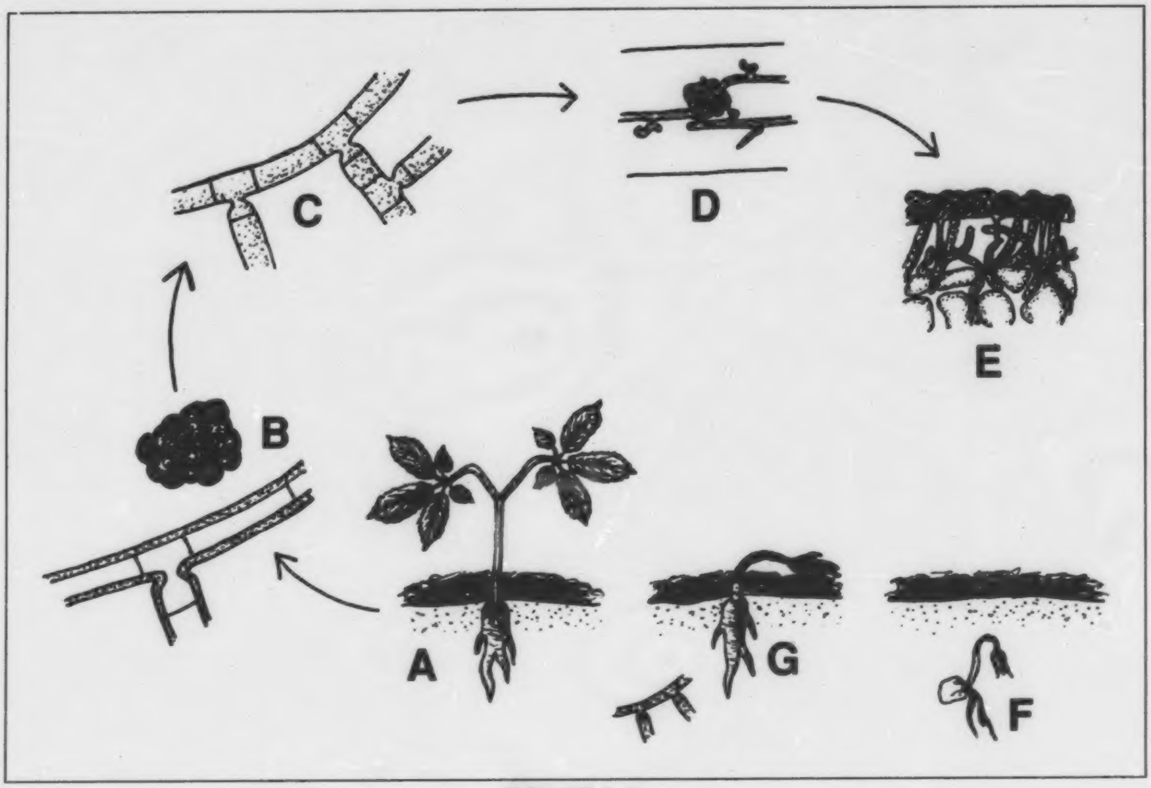


FIGURE 6–2.
Life Cycle of *Rhizoctonia* on Ginseng

A. *Rhizoctonia* spreads through the soil as hyphae (fungal threads). This fungus does not normally produce spores.
B. The fungus overwinters as mycelium in decayed root tissue or as sclerotia – small knotted masses of mycelium (many hyphae). The sclerotia are resistant to cold and drought and can withstand many chemical treatments.
C. There are many strains of *Rhizoctonia*. The one that attacks ginseng prefers cool temperatures and damp conditions. The presence of *Rhizoctonia* mycelium is diagnostic of the presence of the fungus. It can travel fair distances through the soil and has been found wrapped around soil particles blowing on the wind. *Rhizoctonia* can grow rapidly under ideal conditions.
D. When *Rhizoctonia* mycelium encounters a susceptible root, usually young, it travels along the root surface and forms dense, matted, infection cushions. The energy from these infection cushions is used to penetrate the cell wall and invade the root (E.). These infections cause pre-emergent decay (F) and post-emergent damping-off (G).

that causes the top of the plant to wilt. Older roots are seldom attacked by this fungus as it does not have the strength to penetrate the older, tougher cell walls.

Symptoms can be confused with those of *Cylindrocarpon destructans* (disappearing root rot), especially in the fall.

Factors Promoting Disease

There are two strains of *Rhizoctonia* in Ontario that attack ginseng. One strain prefers the cool, damp soil in early spring and will attack plants as or shortly after they emerge. This same strain can be active during the fall and into the winter. The second strain can be active in the hot summer months. The summer strain causes symptoms that resemble those of infection by *Fusarium*. Since the fungus travels vegetatively (by means of mycelial growth) through the soil from plant to plant, gardens with a high plant density will show a more extensive spread of the disease.

High nitrogen levels that promote rapid plant development will leave roots and stems susceptible for longer periods of time. Growth that is too rapid does not allow plants to harden off quickly.

Disease Management Practices

Cultural Control

The fungal threads of *Rhizoctonia* can cling to soil particles. Movement of this soil into gardens can spread the disease. Soil can move on wind, water, machinery and the boots of people who pass through the garden. New gardens should not be situated where they will receive runoff from existing gardens or vegetable fields. Workers and machinery should move from new gardens to older gardens, never the reverse. Care should be taken not to introduce unfumigated soil onto beds as they are formed.

Chemical Control

See Table 7–5, *Disease Control Recommendations for Ginseng in Ontario*, on page 63, for chemical recommendations for the control of *Rhizoctonia* diseases of ginseng. Chemical treatment for the control of *Rhizoctonia* can be dependent on the population of the fungus in the soil. In soil with high levels of *Rhizoctonia*, especially following successive plantings of soybeans, there will be enough "escapes" from both fumigation and treatment to cause disease. It may be worth noting that excessive use of Quintozene may favour the occurrence of *Fusarium*, *Pythium* and *Cylindrocarpon*.

Phytophthora Root Rot and Blight of Ginseng

The Fungus and Symptoms

Phytophthora root rot is caused by the fungus *Phytophthora cactorum*. This fungus can attack a number of fruit and vegetable crops. It is a close relative of the fungus that causes late blight in potato. *Phytophthora* is a soil-borne fungus and belongs to a group of water-loving fungi called oomycetes (oh-oh-MY-seats). This fungus can attack both the roots and the foliage of ginseng.

Phytophthora root rot is a serious disease of ginseng and can cause severe economic loss. If the fungus is present in the soil in the form of mycelia (fungal threads) or oospores (the resting spores of *Phytophthora*), it can infect plant roots at temperatures above 6°C. Roots can be invaded by the mycelium or by small swimming spores called zoospores. The zoospores are equipped with two "tails" that enable them to move through the water phase of the soil. Although they have this ability, they seldom move on their own more than a few centimetres. Zoospores are produced in structures called "sporangia" (or zoosporangia). The sporangia are formed from germinating oospores and from mycelium in decaying plant tissue, either roots or leaves. Depending on environmental conditions, sporangia may directly form mycelium in the soil.

Once the root is invaded by *Phytophthora*, the plant tissue degenerates and becomes softened. The outside of the root remains dry and takes on a characteristic pinkish-brown colour (see PLATE 61 on page 83). A distinguishing feature of this root rot is the presence of soil that "clings" to the root after it is pulled. The root interior loses its integrity and becomes a creamy-coloured, "cheesy" mass (see PLATE 62 on page 83). As the disease progresses, the root disintegrates and in advanced stages there is nothing left at the base of the stem but a soft lump caked with soil. Moisture, usually clear, will exude from the root when it is squeezed, but the root is not slimy. Above-ground symptoms of phytophthora root rot are most often found on the edges of the trenches. The wilting of a single leaf is a typical first symptom (see PLATE 63 on page 83). Wilted leaves have a dark, water-soaked appearance. Eventually, the entire plant wilts, and the stem topples over (see PLATE 64 on page 83). In wet seasons, soil can become saturated or nearly saturated in the beds. Roots that extend into this wet layer can become infected and plants in the centres of beds may show disease symptoms. Once these conditions exist in a garden, it becomes increasingly difficult to control the spread of the disease and the subsequent destruction of roots.

Splashing water can carry zoospores, sporangia and even soil containing mycelium onto the leaves. If sufficient moisture is present, the fungus will rapidly grow into the leaf tissue. Many sporangia will develop on leaf lesions. The *Phytophthora* that causes late blight in potatoes will form more than 900,000 sporangia on a single leaf lesion. The sporangia are easily dispersed on air currents. The leaf blight phase of the disease spreads rapidly throughout the garden. Sporangia from leaf lesions drop onto the soil and begin the invasion process of the roots. Foliar infections begin as dark, water-soaked areas (see PLATE 65 on page 83) that may become tan in colour as they dry. The leaf tissue soon becomes covered with a light grey, cottony mass of mycelium, and, under moist conditions, sporangia develop.

The fungus overwinters as oospores or as mycelium in diseased plant tissue and as oospores in the soil.

Factors Promoting Disease

Phytophthora is a water-loving fungus. Disease is most prevalent where soil moisture is above 60% field capacity or where there is water pooling in the garden (see PLATE 66 on page 83). Because the fungus can be active at temperatures as low as 6°C, roots are vulnerable early in the spring and through the growing season.

The movement of machinery and people through standing water can splash the fungus up onto the beds and onto leaves. Rain can splash zoospores and

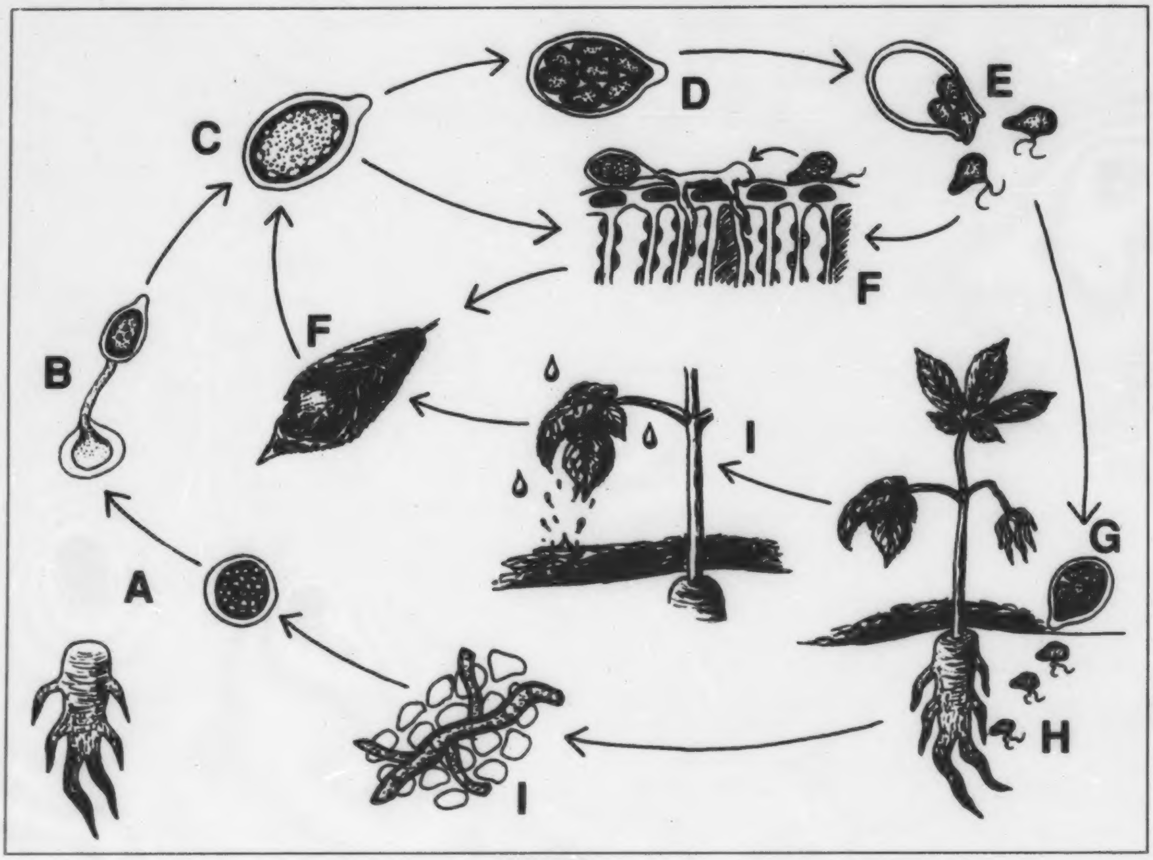


FIGURE 6–3.
Life Cycle of *Phytophthora* on Ginseng

A. *Phytophthora* overwinters primarily as oospores (oh'-oh-spores). These are survival structures with thickened coats to resist low temperatures and dry conditions.
B. When conditions are right, moist soil above 6°C, the oospores germinate to form sporangia.
C. The sporangia can disperse with water flow or on air currents.
D. Sporangia contain many swimming spores called zoospores.
E. Zoospores can be released on the surface of leaves or stems or they can burst in the soil water matrix (G.). Sporangia can also germinate directly into mycelium. Whether zoospores or mycelium are produced depends on temperature and moisture conditions.
F. Sporangia or zoospores that land on leaf tissue can germinate to form water-soaked lesions. These lesions soon become covered with mycelium and many sporangia develop. These sporangia can disperse on air currents throughout a garden and possibly to other gardens in the vicinity.
H. Zoospores can move about 3–6 cm in the soil water. Mycelium can travel 3–6 m per year but will differentiate into sporangia when conditions are not ideal. When zoospores reach root tissue, they encyst and attach themselves firmly (they become adhesive) to the root surface. From there they invade the root and begin to rot the root tissue. There are many obstacles to zoospores under field conditions, and not all zoospores reach new roots.
I. Zoospores and sporangia that are present in the soil can be splashed onto garden beds by machinery moving through the trenches and by rainfall. Rainfall can move sporangia up to 1 metre by splashing. Mycelium (fungal threads) can move out from infected roots and travel through the soil 3–6 m per year to infect surrounding roots.

sporangia up to 1 metre. Excessive fertilization that results in a dense leaf canopy will create ideal humid conditions for the development of leaf lesions.

Disease Management Practices

Cultural Control

Management of *Phytophthora* begins with site selection. Before planting ginseng, a topographic analysis is needed. Land should be evaluated for surface runoff patterns and low areas where water can pool or soil remains wet for long periods of time. Sub-surface drainage should be assessed either by a soil profile or by using a soil probe. Tiling should be considered as a means of reducing sub-surface water levels. The directions of beds will depend to a good part on the direction of the movement of surface water. New gardens should not be situated where runoff from existing gardens is likely to flow.

Once the site is chosen and beds are formed, grading the garden should be addressed. Trenches should be above the level of surrounding soil. It may be necessary to dig a perimeter trench to promote rapid water movement. It may also be necessary to direct surface water away from the garden area to an area where pooling is more appropriate. Subsoiling of the trenches is a consideration where wet areas persist.

In low areas where water can pool in trenches, the trenches should be partly filled with bark chips or gravel to avoid splashing. Stay out of gardens immediately after a rain.

Equipment should be used in younger gardens first, washed off before entering another garden and used in older gardens last. People moving through the garden should wear disposable plastic "booties" and change them between gardens. The impact of equipment on dispersal of this disease cannot be stressed enough. A single focal point of disease can translate into disease along every driveway in a matter of weeks when equipment drags infected soil and water throughout the garden.

Chemical Control

Preventive measures are the only effective means of managing *Phytophthora* in ginseng gardens. Use an integrated approach that combines both Ridomil and Aliette and begin the program early in the spring, as soon as the soil warms to 6°C. See Table 7–5, *Disease Control Recommendations for Ginseng in Ontario*, on page 63, for recommendations for the effective use of these control measures. Particular attention should be paid to the volume of water applied with Aliette. Good resistance management practices are imperative. Repeated use of Ridomil can result in the development of resistant strains of *Phytophthora.* Refer to the section *Fungicide Resistance* on page 44.

Spray coverage is important in any protective program. Make sure the sprayer is reaching all plant parts. Avoid plant stress due to the development of other ginseng diseases. Never use rates of disease control products or suggested water volumes lower than those recommended on the label.

Alternaria Diseases of Ginseng

The Fungus and Symptoms

Alternaria diseases of ginseng are caused by the fungus *Alternaria panax.* There are many *Alternaria* species infecting many horticultural crops. Some species like *A. alternata* have a very broad host range, but species such as *A. panax* attack a narrow range of host plants. *Alternaria* spores are present everywhere. They move about on air currents. *Alternaria panax* can be found throughout the ginseng-producing areas of the world. Spores have a distinctive shape under the microscope

In ginseng gardens, most *Alternaria* infections begin on stems early in the season. The fungus requires a definite period of humidity at various temperatures to cause infection. Once the plant canopy opens, the stems are sheltered by the leaves and a humid microclimate results. The first signs of stem infection are light or tan-coloured areas on the stem above the mulch. These areas soon become dry and brittle. As infection proceeds, they become covered with a "sooty" layer of dark spores. A sooty residue will remain on a finger that has been rubbed along the dark portion of the lesion. Stem lesions resulting from *Alternaria* usually cause the stem to buckle at the lesion and topple at a sharp angle (see PLATE 67 on page 84). Stem lesions caused by *Rhizoctonia* are not as brittle, and the stems bend in an arc, until, of course, the stem collapses. Another difference between the two types of stem lesions is in their placement on the stem. *Alternaria* tends to be above the mulch layer while *Rhizoctonia* is lower on the stem, either within the straw layer or just above the soil.

Foliar symptoms of *Alternaria* are usually distinctive. Typical lesions consist of a dry, tan centre area surrounded by concentric dark and light areas and ultimately surrounded by a chlorotic "halo" (see PLATE 68 on page 84). The dark areas are where the spores are formed. Lesions are circular or roughly angled in a circle. Severe infections on the peduncles, especially at the leaf axil, can cause defoliation. The peduncles are the short "stems" that hold the leaves and flower head. Unchecked, *Alternaria* can defoliate an entire garden in less than a week if weather conditions are conducive to disease (see PLATE 69 on page 84).

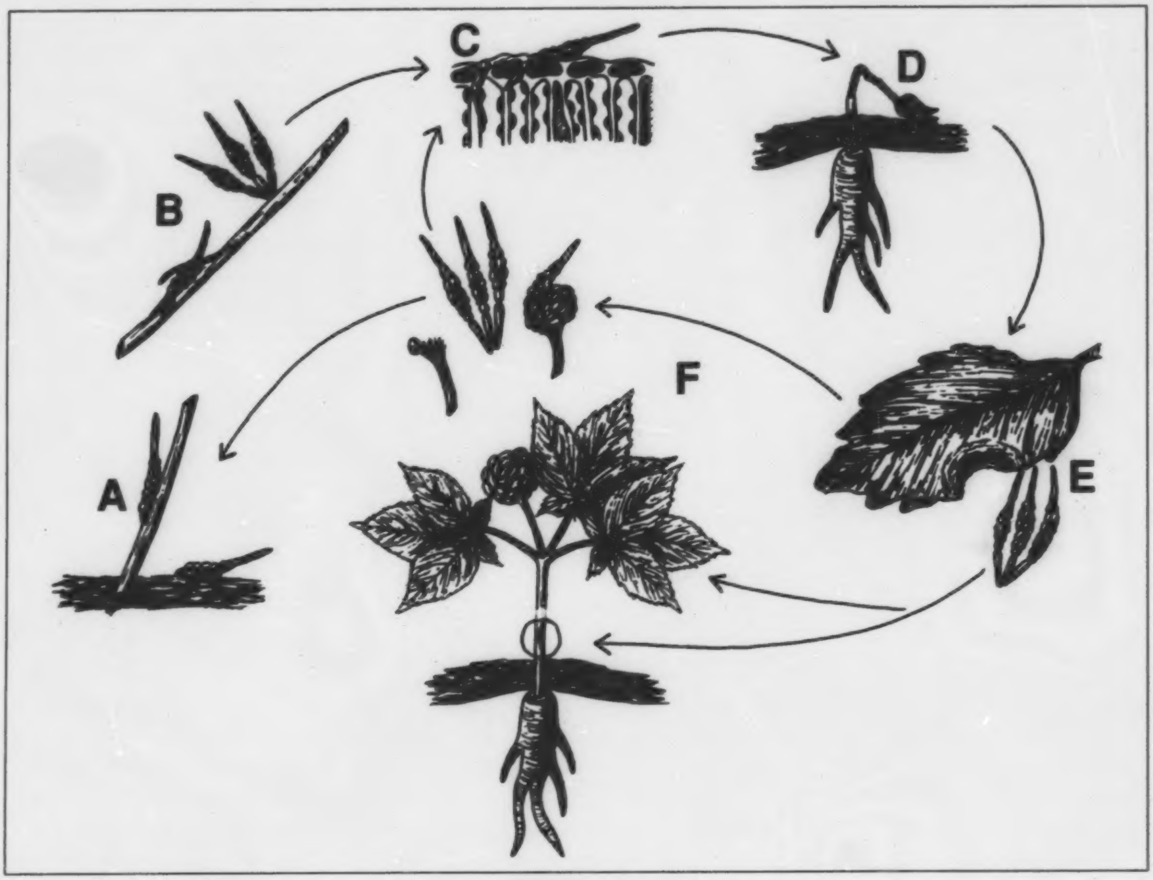


FIGURE 6–4.
Life Cycle of *Alternaria* on Ginseng

A. *Alternaria* conidia (spores) overwinter on ginseng refuse such as old stems or fallen leaves. Conidia remain alive throughout the winter ready to germinate in the spring.
B. As the conidia germinate, they send up many stalks that produce more conidia. These new conidia are ready to infect nearby plants and can be moved about on air currents and as people or machinery move through a garden.
C. *Alternaria* conidia are multi-celled. Each cell is capable of germinating and invading plant tissue.
D. The first infections that occur in gardens where there was *Alternaria* the previous year will be on stems. These infections often go unnoticed until a "hot spot" forms and a number of leaves surrounding the old plant material develop lesions.
E. Leaf lesions are usually tan coloured and have a yellow border. Areas where conidia are produced make darker circles within the lesion and give it a "target spot" appearance. Thousands of conidia are quickly produced on leaf lesions.
F. Conidia produced on leaf lesions move on air currents throughout the garden and from garden to garden. New stem lesions are formed and developing seed heads are also attacked. When seed heads are attacked, the berries usually abort, and nothing is left but the tiny peduncles (flower stalks) that once held the berries. This form of the disease is often called "blast." Plants need protection on all above-ground parts for control to be effective. Good coverage is essential on the stems and flower heads.

Atypical lesions can occur under extremely hot conditions. In hot weather, the lesions may be dark brown or black and have a "greasy" appearance. Close examination will still reveal the concentric circles of sporulation. On seedlings in hot weather, stem lesions can cause the stem to become almost black and collapse. This results in leaf wilting and an appearance similar to damping off.

Once established in a garden, spores will spread to developing seed heads. Berries on infected heads will become dark and shrivelled (see PLATE 70 on page 84). Eventually they will drop off the plant, leaving only the stalks.

The fungus overwinters on the straw and on plant debris. In the spring, spores are formed and move on air currents to emerging plants.

Factors Promoting Disease

If *Alternaria* is present in a garden, spores will be present on plant debris throughout the winter. This is especially true of old stems. It is not unusual after the canopy opens in the spring to find a group of plants with foliar lesions surrounding a stem still standing from last year. Plant debris is the most frequent source of spring infections in ginseng gardens.

Because the disease requires humidity to become established, a lush plant canopy promotes the development and spread of stem and foliar lesions. Gardens located in areas of "dead air" next to woodlots are more likely to develop hot spots. Later in the season, spores are blown into gardens from other infected gardens and from any nearby host plants.

Gardens with a low pH will be more severely affected by *Alternaria.* The disease is more common on senescing plant tissue. As gardens age throughout the season, they will be more susceptible to disease. Gardens stressed by poor fertility, fertilizer burn, air pollution and mechanical stresses such as hail or drought will be more likely to develop disease.

Disease Management Practices

Cultural Control

Gardens should be located where air can move freely. If side shades are erected, they should not restrict total air movement. Large gardens should be "vented" by raising the lath or cloth at intervals to allow heated air to escape. All practices that reduce humidity will help prevent infections.

Before planting, soil pH should be between 6 and 6.5.

Plant density can affect the development of disease. High seeding rates or fertility practices that promote lush foliage create an environment conducive to disease. Ginseng self-thins to about 80 plants/m^2 after 3 years. High seeding rates not only affect the microclimate in the leaf canopy but lead to smaller, thinner roots.

Chemical Control

Early application of Bravo, at 20% emergence, should help to "clean up" the mulch and prevent early spring infections. Once the plant canopy has opened, alternate chemical families. Pay close attention to water volume, tank mixes and coverage. To be effective agents in the prevention of *Alternaria,* control chemicals must cover the stem and seed heads as well as the upper and lower leaf surfaces. Refer to Table 7–5, *Disease Control Recommendations for Ginseng in Ontario,* on page 63, for the chemical control recommendations for *Alternaria* diseases of ginseng.

Botrytis Blight of Ginseng

The Fungus and Symptoms

Botrytis blight of ginseng is caused by the fungus *Botrytis cinerea.* This fungus is a pathogen of many fruit and vegetable crops and causes the "grey mould" rot that is common to grapes, strawberries, greenhouse floral crops and many vegetables. *Botrytis* is most active at cool (18°C–23°C) temperatures. It can infect all parts of the plant from flowers, leaves and stems to roots.

It frequently becomes established on plants toward the end of the flowering period. The fungus infects the dying tissue of spent petals. It does not generally invade healthy, growing tissue but when it builds up enough mass on the dying petals, it is able to penetrate any tissue that it contacts. This ability to invade dead and dying tissue makes it particularly threatening to ginseng. *Botrytis* spores that lodge in the straw can germinate and develop "sclerotia," hard, black bodies that can survive winter temperatures and adverse conditions (see PLATE 71 on page 84). These sclerotia resemble small mouse droppings. When weather conditions are appropriate (cool and humid), the sclerotia germinate, resulting in many spores being produced and released.

Flowers that become infected will produce a mass of "fuzzy" grey conidia (spores). Adjacent berries will turn purplish and shrivel (see PLATE 72 on page 84). As the berries decay, they, too, will produce many conidia (see PLATE 73 on page 85). The mass of mycelia (fungal threads) produced by these infections will invade any adjacent tissue of leaves and stems that come in contact. Sometimes a series of decaying leaves will "stick" together. As one leaf decays and collapses onto another, the other becomes infected (see PLATE 74 on page 85). This chain reaction of infection creates hot spots in a garden. During periods of high humidity, many conidia are released from "hot spots" to form new infection areas.

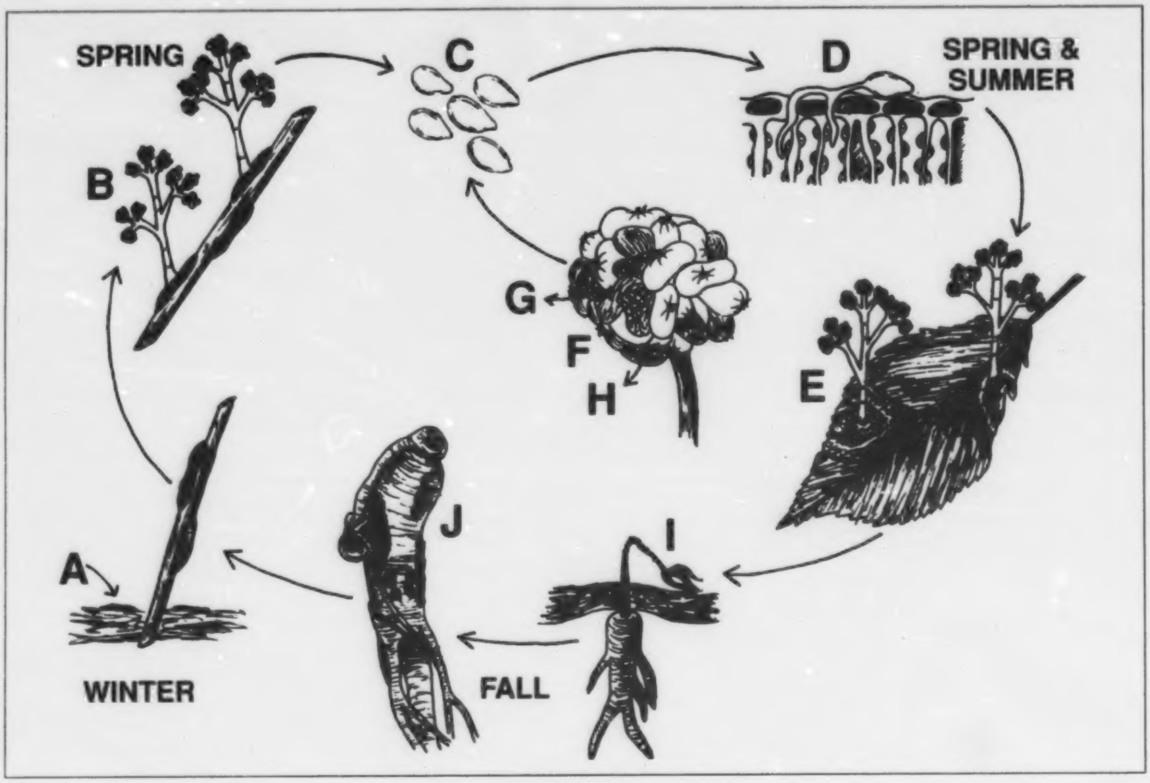


FIGURE 6–5.
Life Cycle of *Botrytis* on Ginseng

A. *Botrytis cinerea* is a fungus with a wide host range. It invades weakened or dying plant tissue. Conidia of *Botrytis* are present wherever plants grow. In the fall, conidia may blow into a garden on the wind or they may be on diseased plants within the garden. The fungus forms survival structures called "sclerotia" that resemble mouse droppings as well as "dark hyphae" that invade dying or dead plant tissue.

B., C. In the spring, these survival structures germinate to form "conidiophores" that produce many new conidia.

D. During the spring and summer, the conidia disseminate throughout the garden. Any plants that are damaged mechanically will be especially susceptible to *Botrytis*.

E. Wherever lesions form on leaves, many conidia are produced and the cycle continues. As leaves become infected, they collapse and drop onto healthy leaves. The nutrient "push" from the decaying tissue gives the fungus the energy it needs to invade healthy leaves.

F., G., H. As flowers begin to senesce, the decaying petals are invaded by *Botrytis*. The fungus uses the decaying petals as a nutrient base to invade developing berries. Newly infected berries have a purplish hue. Once the fungus becomes established, conidia form abundantly on the decaying berries.

I., J. The microclimate in the interior canopy of a ginseng garden can be very warm and humid. Under these conditions, *Botrytis* may infect the stem just above the straw. These stem infections can move into the rhizome and also the root. Root infected with *Botrytis* rots quickly and may disappear between the autumn and subsequent spring.

Leaf symptoms usually begin at the tip or leaf edge (see PLATE 75 on page 85). Sometimes, if there has been mechanical damage, they will begin in the middle of the leaf. Infected leaf tissue turns pale, then tan, then "glassy." The rot is soft, and affected areas are quite wilted (see PLATE 76 on page 85).

Stem rot also produces a soft lesion, unlike the brittle lesion caused by *Alternaria* or the dry lesion caused by *Rhizoctonia*. Infected stem tissue becomes soft, tan-coloured and eventually covered with a mass of grey mycelium and conidia (see PLATE 76 on page 85).

Damping off of seedlings can occur in a cool, humid season, especially after sandblasting. In these cases, the root is usually invaded and completely disappears.

Although not traditionally considered a root-rotting fungus, lower stem infections can move into roots and cause decay. *Botrytis* root infections may be associated with the reduced plant stand in ginseng gardens over time (see PLATE 77 on page 85).

Factors Promoting Disease

Anything that causes mechanical damage to the leaf will predispose that leaf to infection by *Botrytis.* In Ontario, sandblasting that occurs early in the season can wound leaves and open them to infection. These infections occur at the edge of gardens. Mechanical injury can also occur from fallen shade, hail and the movement of machinery and people through the garden. Leaf burn from fertilizers or pesticides can also precede infection. Gardens are especially susceptible after flowering. Ginseng flowers over a 4–6-week period, and infection can occur anytime after the first flowers senesce. Infected petals can drop onto leaves or other flower heads, continuing the disease cycle.

Temperatures below 23 °C and high humidity will promote disease. Humidity remains high within the plant canopy even when the outer surface of the leaves is dry. Sclerotia on the straw, dropping infected petals and falling conidia will easily infect lower stem tissue. A dense plant canopy will maintain high humidity for extended periods of time. There is higher likelihood of infected leaves contacting healthy leaves when the canopy is dense.

There will be masses of spores produced in the spring where sclerotia have formed on the straw. Because so many different plants are affected by *Botrytis,* it is likely that conidia will lodge in the straw sometime during the season, even in a disease-free garden.

Disease Management Practices

Cultural Control

Removal of decaying plant debris will reduce the presence of *Botrytis.* Ginseng tends to thin out to about 80–100 plants/m^2. Initial seeding rates higher than this will promote a dense, humid environment within the canopy. Fertility practices that result in lush canopy development will also result in high humidity. This within-canopy humidity promotes *Botrytis* rot at the base of the stem just above and within the straw mulch.

Guards on machinery that prevent leaf abrasion will lessen disease. Workers should be cautioned to move through the garden with care.

A 1-m rye strip around the perimeter of the garden will help to prevent sandblasting.

Chemical Control

Refer to Table 7–5, *Disease Control Recommendations for Ginseng in Ontario,* on page 63, for information on chemical control of *Botrytis.* Timing of *Botrytis* controls should coincide with periods of susceptibility.

Cylindrocarpon Diseases of Ginseng

The Fungus and Symptoms

Cylindrocarpon is a soil fungus closely related to *Fusarium.* It is found worldwide in ginseng-growing areas. One of the most severe diseases of ginseng, it is frequently found associated with seed after stratification in buried seedboxes.

Seeds infected with *Cylindrocarpon* may decay and be culled out as "floaters." However, many infected seeds do not decay, and the only evidence of *Cylindrocarpon* infection is the pink or white "sporodochia" on the seed surface. Surface sterilization will eliminate the threat from this fungus on the seed surface but will not eliminate the fungus from the interior of the seed. Visual culling of seeds with sporodochia is the only way to avoid planting these infected seeds in the garden.

Seedlings attacked by *Cylindrocarpon* may die before or after emergence. The fungus can attack the root and cause a dark rot that destroys the entire root (see PLATE 78 on page 85). The fungus can also be associated with seedling roots (see PLATE 79 on page 86). *Cylindrocarpon* has been recovered from roots that are stubby (see PLATE 80 on page 86) or have a "rusty" netting on the surface. Occasionally these plants may go on to harvest with no further decay.

Cylindrocarpon is more commonly associated with older roots. Spores of the fungus are stimulated by root exudate (substances that leach out of the root) and when the spores are present in a garden, more plants will become diseased as the garden ages. Gardens that have a population of plants infected with this fungus in the second year will have at least double that infection level early in the third year. In older gardens, disease spreads rapidly towards the end of the season.

Above-ground symptoms of *Cylindrocarpon* infection are often no more than colouring of the leaves (see PLATE 81 on page 86). The disease is most frequently associated with red leaf perimeters. This can be confused with *Phytophthora* where leaves can take on a reddish tinge and with *Fusarium* where leaf perimeters are often reddish and yellow. Wilting plants are a sign of advanced decay (see PLATE 82 on page 86).

The most common root symptom of infection by *Cylindrocarpon* is "disappearing root" rot. Roots with this symptom are reduced in the advanced stages to a blackened stub (see PLATE 83 on page 86). Earlier symptoms are darkening of the outer areas of the root and a definite scaling of the root surface (see PLATE 84 on page 86 and PLATE 85 on page 87). Once again, the scaly area often covers an orange, spongy layer just below the surface. Spores are most frequently produced later in the season and are quite distinctive under the microscope. When these symptoms are present in a garden, it usually indicates that the pathogen is very aggressive and spread can be amazingly rapid.

Symptoms of rusty root and *Rhizoctonia* infections can be confused with the symptoms of *Cylindrocarpon* infection (see PLATE 86 on page 87). Microscopic analysis or growing the fungus on a selective medium is the only way to know what has caused this root decay. It is very important to know what pathogen you are dealing with in this case. If Quintozene is applied for treatment of *Rhizoctonia* infection, *Cylindrocarpon* and *Fusarium* may be more aggressive.

Factors Promoting Disease

In spite of its seriousness and worldwide efforts to control this disease, little is known about the factors that promote infection. *Cylindrocarpon* can be present in a garden, and few plants may succumb. In other gardens, plant loss may be as high as 90%.

There are, nevertheless, some factors that are becoming evident. *Cylindrocarpon* is more prevalent in areas of former fencelines. It is more common near forested areas and in areas where brush has recently been burned. Gardens where there is excessive nitrogen use have more severe disease outbreaks, as do gardens where Quintozene has been applied more frequently.

This disease can be introduced into a garden via seed and seedbox contamination.

Refer to the section *Nitrogen Fertilizers* on page 22 for a discussion of nitrogen management in soils.

Disease Management Practices

Cultural Control

There is little a grower can do to prevent or avoid *Cylindrocarpon* other than culling out seed with sporodochia.

Garden sanitation is essential. Equipment should be washed between gardens. Workers should wear disposable "booties."

Site selection is probably the most important factor in cultural control at this time. Growers should stay away from areas recently forested and from former fence rows.

Site selection is also important for the seedbox. *Cylindrocarpon* can be picked up on the seed, and infected seed can be transported to new gardens. It is not clear whether the seed picks up *Cylindrocarpon* in the seedbox during burial or on the plants during seed development. Controlled stratification above ground may help to prevent seedbox contamination.

Chemical Control

There are no chemicals registered for use against *Cylindrocarpon.*

Rusty Root

Root symptoms associated with *Cylindrocarpon* can vary. "Rusty root," sometimes referred to as "scab," can be associated with *Cylindrocarpon* infections. Scaly, rust-coloured areas (see PLATE 87 and PLATE 88 on page 87) develop on the tap root, usually near a fibre or branch, and may or may not penetrate to the root interior. It is possible that these areas can be sloughed off without further root rot. An "orange" crumbly layer underneath the surface of rusty lesions usually indicates the presence of *Cylindrocarpon.* Spores of the fungus cannot always be found, especially early in the season, and diagnosis may take 2–3 weeks after incubation of the fungus on highly specific media. This type of lesion is easily mistaken for *Rhizoctonia* (see PLATE 89 on page 87) and only a microscopic diagnosis followed by culture of the fungus will tell the two apart. Sometimes, root rot continues, and the plant dies.

Research from Korea and British Columbia has indicated that rusty root can be caused by adverse environmental conditions. Low temperature injury, especially in areas where the straw layer is insufficient, may result in rust forming on the crown and/or bud of the roots

TABLE 6–3.
Quick Disease Reference for Ginseng

Disease	When to Look	Where to Look	What to Look for
Rhizoctonia	• throughout the season • especially in seedling and 2-year gardens	• on the stem within the mulch • on the crown area of the roots	• dry tan lesion on the stem • rusty lesions on the crown and/or bud
Botrytis	• throughout the season • after mechanical damage • during humid weather	• on the straw • on leaves within the canopy • at the base of stems • on flowers and berries	• black sclerotia on the straw • soft lesions on leaves at the edges or tip • leaves appear to "melt" and stick to adjacent leaves • soft brown lesions • dark brown or purplish berries
Alternaria	• throughout the season	• on the stem above the mulch • on the leaves • on the flower head and seed head	• brittle tan lesion on the stem, "sooty" spores • leaf lesions with "halo" • tan leaf lesions with concentric circles of light and dark • water-soaked or black lesions in hot, humid weather • dry, brown berries • dry brown flower and/or seed stems
Phytophthora	• in wet areas • after prolonged wet weather	• along the edges of the beds • beside standing water • where water splashes into the middle of the beds	**Root Rot** • soft, dark, collapsed leaves • one leaf wilts first • leaves may have "purplish" tinge • roots pinkish brown with "cheesy" interior **Leaf Blight** • dark-green, soft lesions beginning at the tip • cottony fungal growth
Fusarium	• throughout the season	• on the stem within the mulch • on the main root or fibres	• shriveled tan lesion on the stem • leaves may have reddish borders • plants may wilt and droop just below the junction of the leaves
Cylindrocarpon	• throughout the season • especially in 3- and 4-year gardens	• on the root	• dry, rusty lesions on the main root, crown or fibre roots • dark, crusty lesions on the main root • leaf symptoms may not be present or may resemble those of *Fusarium*

(see PLATE 90 on page 87). Other adverse environmental conditions associated with rusty root are excess nitrogen levels, high organic matter content in the soil, unbalanced mineral levels in the soil and excess water.

Abiotic Disorders of Ginseng

Heat Stress

Under conditions of extreme heat and drought, ginseng leaves will develop dry, tan areas (see PLATE 91 on page 88). These areas can easily be confused with symptoms of fungal infection. This disorder is also called "papery leaf spot," which aptly describes the condition. Once symptoms occur, there is little that can be done to revive the damaged tissue. Papery leaf spot can be prevented to some degree by allowing hot, humid air to escape from gardens through a series of vents where the shade material is slightly raised at intervals. Irrigation may also prevent symptoms. Any irrigation in ginseng must be balanced with the risk of phytophthora root rot.

Air Pollution

Both ozone and sulphur dioxide can have an effect on ginseng leaves. Symptoms of air pollution in ginseng include bleached, whitened areas on the leaves (see PLATE 92 on page 88). These areas are usually the size of a nickel but may be larger. They can occur at the base of the leaflets, in the middle of the leaflets along the main vein or at the leaflet tips. This same symptom can indicate herbicide damage due to drift. A check of surrounding weeds can usually rule out (or confirm) herbicide drift.

Boron Toxicity

Ginseng requires boron for growth and development, but too much can damage the plant. Excess boron can result in small root weight and even in a root condition similar to rusty root. The most obvious symptom of excess boron occurs on the leaves. The leaf edges will appear yellow or white and will dry out (see PLATE 93 on page 88). If symptoms of boron toxicity appear in your garden, check fertility records to determine whether there may have been an application or measurement error. Boron toxicity can be confirmed by tissue analysis.

Herbicide Drift

Occasionally, herbicide applied to neighbouring fields or in a perimeter area may drift onto a ginseng garden. If drift of a product containing glyphosate occurs in the fall, even after the ginseng has senesced, there may be residue on the straw the following spring. This does not always occur, and environmental conditions play a role in such a carry-over. Symptoms may be visible in emerging plants in the spring (see PLATE 94 on page 88) as distorted, strap-like leaves. If drift has occurred, there will be a discernible pattern to the area of damage. Damage can be confused with slug damage and with cold temperature damage. Analysis of the leaf tissue is the only way to know if herbicides have caused the symptoms.

Herbicide Residue in the Spray Tank

Spray equipment used to apply herbicides should not be used to apply other pest control products. If glyphosate has been used in a spray tank, there will be some residue that adheres to the tank surface. Bravo will strip that residue from the tank surface and leaf burn can result (see PLATE 95 on page 88). This reaction is specific to that herbicide/fungicide combination.

Foliar Fertilizers Mixed With Fungicides

Dithane fungicides contain small amounts of zinc. If foliar fertilizer containing zinc is added to the tank, leaf burn can result (see PLATE 96 on page 88). Under warm or hot environmental conditions, the leaf burn can be severe enough to cause serious damage to the crop. Extensive leaf burn will result in smaller than average roots.

7. Pest Control Recommendations

TABLE 7–1.
Preplant Fumigation in Ginseng

Target Pests	Product	Product Rate	Chemical Name	Comments
nematodes	Vorlex Plus	55–130 L/ha	methylisothiocyanate, 1,3-dichloropropene and other related C_3 hydrocarbons	Rates are for mineral soils. Use higher rates for disease control.
nematodes, soil-borne diseases, weeds, wireworms	Vorlex Plus CP	225–450 L/ha	methylisothiocyanate, chloropicrin, 1,3-dichloropropene and other related C_3 hydrocarbons	Rates are for mineral soils. Use higher rates for disease control.
nematodes	Telone II B	See label.	1,3-dichloropropene	See label.
nematodes, soil-borne diseases	Telone C-17-R	See label.	1,3-dichloropropene, chloropicrin	Use higher rates for disease control.
nematodes, soil-borne diseases, weeds	Vapam	550–900 L/ha	metam-sodium	Lower rates adequately control nematodes. Apply by soil injection.
nematodes, soil-borne diseases and weeds	Busan 1020	700–935 L/ha	metam-sodium	Lower rates adequately control nematodes. Apply by soil injection.
nematodes, soil-borne diseases and weeds	Basamid	325–500 kg/ha	dazomet	Apply as a granular with a spreader then incorporate immediately.

TABLE 7–2.
Insect Control in Ginseng

Target Pest	Product	Product Rate	Chemical Name	Comments
cutworms (army cutworm, black cutworm, pale western cutworm, red-backed cutworm, white and/or variegated cutworm)	Pounce	180–390 mL/ha	permethrin	Apply when scouting indicates the presence of cutworms. **Ground application:** Apply in sufficient water to give thorough coverage of the plants. Use the higher rate if the infestation is heavy. **Under dry conditions:** Apply 295–390 mL/ha. **Where worms are large (2.5–4 cm):** Use 295–390 mL/ha. Applications should be made under warm, moist conditions in the evening or at night. Maximum of 2 applications per year.
four-lined plant bug	Pounce	180–260 mL/ha	permethrin	**Ground application:** May be applied up to 40 days to harvest. Maximum of 2 applications per year.

TABLE 7–3.
Weed Control in Ginseng

Good weed control depends on the timing of herbicide applications.
Check the label to find out which weeds are susceptible and at what growth stage treatment is most effective.

Target Weeds	Product	Product Rate	Chemical Name	Comments
annual grasses, perennial weeds (quack grass, Canada thistle, sow thistle, field bindweed, milkweed, cattails, nut sedge, poison ivy, etc.	Touchdown 480 Herbicide	2.5 L/ha in 50–100 L/ha water	glyphosate	In Ontario: **For spring application only.** Apply **pre-emergent to ginseng** when weeds are at the growth stage described on the label. **Do not allow product to contact emerging or emerged ginseng.** Apply only in water volumes described on the label. See directions for use on the label. **Follow the instructions on the label.**
annual grasses, perennial weeds (quack grass, Canada thistle, sow thistle, field bindweed, milkweed, cattails, nut sedge, poison ivy, etc.	Touchdown 640 Herbicide	Use one application of: 1.875 L/ha in 50–100 L/ha water	glyphosate	In Ontario: **For existing/established gardens only.** Apply in the spring before the crop has emerged. Apply when weeds are at the growth stage described on the label. **Use one application only.** **Do not exceed rate or spray volumes or spray injury may result.** DO NOT USE A FALL APPLICATION IN EXISTING/ESTABLISHED GARDENS.
annual grasses, perennial weeds (quack grass, Canada thistle, sow thistle, field bindweed, milkweed, cattails, nut sedge, poison ivy, etc.	Touchdown 600 Herbicide	Use up to two applications of: 2 L/ha in 50–100 L/ha water	glyphosate	In Ontario: **For existing/established gardens only.** Apply in the spring before the crop has emerged. Apply when weeds are at the growth stage described on the label. **Use up to two applications.** **Do not exceed rate or spray volumes or spray injury may result.** DO NOT USE A FALL APPLICATION IN EXISTING/ESTABLISHED GARDENS.
grasses (see label)	Venture L	Maximum of: 2 L/ha at any single application	fluazifop-p-butyl	Maximum of three applications per year. Apply in early May, late June, mid-August. Use ground application only. Do not apply in the year of harvest.

TABLE 7–4.
Rodent Control

Product	Rate	Active Chemical	Comments
rodent pellets rodent bait	Use in bait stations. Place 15 gm (one level teaspoonful) of bait in each station. Place stations 2.5–3.7 metres apart.	zinc phosphide	Bait stations should be tamper-proof. Ensure that dogs, other scavengers and wildlife are not exposed.

TABLE 7–5.
Disease Control Recommendations for Ginseng in Ontario

Target Pest	Product	Product Rate	Active Chemical	Comments
Rhizoctonia	Quintozene 75WP	9.0 kg/ha	pentachloronitrobenzene	Apply as a high volume spray in 3,400–4,500 L water/ha. Apply at the time of seeding before mulching. Do not apply within 24 months of harvest. No other root crops are to be grown for a minimum of 1 year following harvest.
	0-0-6 fertilizer with 15% Quintozene	45 kg/ha OR 4.5 gm/m^2 for spot treatment	pentachloronitrobenzene	Broadcast before or after mulching at the time of seeding. Spot treat if symptoms appear in the first year. Do not apply within 24 months of harvest. No other root crops are to be grown for a minimum of 1 year following harvest.
	0-0-5 fertilizer with 5% Quintozene	135 kg/ha OR 13.5 gm/m^2 for spot treatment	pentachloronitrobenzene	Broadcast before or after mulching at the time of seeding. Spot treat if symptoms appear in the first year. Do not apply within 24 months of harvest. No other root crops are to be grown for a minimum of 1 year following harvest.
	QUADRIS Flowable Fungicide[1]	At the time of seeding after September 30: 1.6 L/ha in 4,000 L/ha water In the spring of the first year before May 1: 0.8 L/ha in 4,000 L/ha water	azoxystrobin	Application to newly seeded gardens should be made after September 30 after the straw mulch has been applied. Spring application should be made before May 1. Do not apply within 2 years of harvest. **CAUTION:** QUADRIS Flowable Fungicide can be extremely toxic to certain varieties of apples and crabapples. Do not apply where there is a possibility of spray drift reaching apple or crabapple trees. Do not use sprayers used to apply QUADRIS Flowable Fungicide to spray apples or crabapples.
phytophthora root rot[2]	Ridomil 2G	31.25 kg/ha	metalaxyl	Make the first application pre-emergent to the ginseng. Repeat twice at 4–6-week intervals depending on weather. Do not apply within 9 days of harvest. Do not apply more than 3 times in one season. Refer to the section *Fungicide Resistance* on page 44.
	Aliette WDG	5.5 kg/ha in a minimum of 200 L/ha water	fosetyl-al	Make the first application between the first two Ridomil applications. Repeat up to 3 times through the season depending on the weather. Make the final application prior to senescence when there is 50% green in the foliage. Do not apply within 30 days of harvest. Do not apply Aliette more than 5 times in one season. Refer to the section *Fungicide Resistance* on page 44.
phytophthora leaf blight	Aliette WDG	5.5 kg/ha in a minimum of 200 L/ha water	fosetyl-al	Do not apply Aliette more than 5 times in one season. Do not apply within 30 days of harvest.

TABLE 7–5.
Disease Control Recommendations for Ginseng in Ontario (Continued)

Target Pest	Product	Product Rate	Active Chemical	Comments
alternaria leaf blight	Dithane M-45	4.4 kg/ha in 2,000 L/ha water	mancozeb	Apply when disease first appears. Do not apply within 30 days of harvest. Alternate with Bravo and Rovral.
	Dithane DG	4.4 kg/ha in 2,000 L/ha water	mancozeb	Apply when disease first appears. Do not apply within 30 days of harvest. Alternate with Bravo and Rovral.
	Pencozeb 75 DF	4.4 kg/ha in 2,000 L/ha water	mancozeb	Apply when disease first appears. Do not apply within 30 days of harvest. Do not feed ginseng foliage to livestock.
	Pencozeb 80 WP	4.4 kg/ha in 2,000 L/ha water	mancozeb	Apply when disease first appears. Do not apply within 30 days of harvest. Do not feed ginseng foliage to livestock.
	Manzate 200 DF	4.4 kg/ha in 2,000 L/ha water	mancozeb	Apply when disease first appears and follow with five subsequent sprays at 2-week intervals as part of a regular spray program. Do not apply within 30 days of harvest. Do not feed treated ginseng (roots or foliage) to livestock.
	Rovral	1.1 kg/ha	ipridione	Do not apply within 30 days of harvest. Do not apply more than 3 times throughout the season. Alternate with Bravo and Dithane.
alternaria leaf spot	Bravo 500F	2.4–4.8 L/ha	chlorothalonil	Do not apply within 14 days of harvest. Do not apply more than 6 times throughout the season. Alternate with Dithane and Rovral.
Botrytis	Bravo 500F	2.4–4.8 L/ha	chlorothalonil	Do not apply within 14 days of harvest. Do not apply more than 6 times throughout the season.

[1] Registration of Quadris at the time of publication is an emergency use for the fall of 2000 and the spring of 2001. The above recommendation does not apply to use beyond that period of time.

[2] Refer to the section *Phytophthora Root Rot and Blight of Ginseng* on page 51 for an integrated *Phytophthora* control program.

TABLE 7–6.
Formaldehyde Seed Soak

Product	Rate	Note
Formalin	• Dilute 1 oz in 140 oz (1 gal) of water. • Soak for 25 minutes. • Rinse with water.	Formalin is a commercial preparation of formaldehyde that contains 37% actual formaldehyde.

8. Appendices

APPENDIX A.
Ginseng Export Regulations

Canada is a signatory of the Convention on International Trade of Endangered Species (CITES). CITES is an international agreement to regulate trade in specific species of wild animals and plants, as well as their respective parts and derivatives. The Canadian Wildlife Service of Environment Canada has been designated as the authority to manage and co-ordinate the application of the Convention in Canada.

The Convention regulates trade in over 30,000 species of wild animals and plants, which are listed in three appendices:

- Appendix I: Rare or endangered species: commercial trade is not normally permitted but permits may be obtained under special circumstances.
- Appendix II: Species that are not currently rare or endangered but that could become so if trade is not regulated: Convention exporting permits must be issued by the government of the exporting nation.
- Appendix III: Species that are not endangered but are managed within the listing nation. Permit requirements are the same as for Appendix II.

Ginseng is listed under Appendix II of CITES. Export permits for ginseng can be obtained from:

The Administrator
Convention on International Trade of Endangered
Species of Wild Fauna and Flora
Canadian Wildlife Service
Environment Canada
Ottawa, Ontario, Canada K1A 0H3
Phone: (819) 997-1840

Permits are issued on an annual basis and cover all shipments made within that year. Once obtained it can be photocopied for future use but Canada Customs must stamp it.

One-time registration forms for use in Ontario can be obtained from the Canadian Wildlife Service office in Guelph by calling (519) 826-2100. This permit is good for a single export shipment.

The Convention, and the legislation through which it is applied, regulates international trade and does not impinge upon trade within a nation or upon provincial or territorial management of species.

APPENDIX B.
Diagnostic Service

Samples for disease diagnosis, insect or weed identification, nematodes counts and *Verticillium* testing can be sent to:

Pest Diagnostic Clinic
Laboratory Services Division
University of Guelph
95 Stone Road West
GUELPH, Ontario, N1H 8J7
Tel: (519) 767-6256
Fax: (519) 767-6240
E-mail: pdc@lsd.uoguelph.ca

Payment must accompany samples when submitted. Submission forms are available at: www.uoguelph.ca/pdc

Fee Schedule

Procedures	Price/ Sample
Plant Diseases	
Diagnosis not requiring plating	$25.00
Diagnosis requiring plating	$40.00
Turf diagnosis	$50.00
Bacterial identification using Biolog®	$95.00
Detection of virus using Transmission Electron Microscopy	$85.00
Detection of virus using ELISA (turnaround time ≈ 5 working days; bulk rates available)	$60
Weed identification	$40.00
Insects	
Basic identification	$25.00
Identification requiring dissection and/or extensive keys	$40.00
Nematode and Verticillium Counts	**Price/ Sample**
Nematodes extracted from soil (Bearman Pan Method)	$25.00
Soybean Cyst Nematode & Egg Count	$35.00
Nematodes extracted from roots	$60.00
Verticillium count	$60.00

Turnaround Time:
Nematodes extracted from soil takes 7 or 8 days.
Nematodes extracted from roots takes 15 days.
Cyst count takes 3 or 4 days.

Charges will be applied to each sample submitted. Payment: Please make cheque payable to the University of Guelph. VISA and Mastercard are also accepted. Please do not mail cash.

How to Sample for Nematodes

Soil

When to Sample

Soil and root samples can be taken at any time of the year whenever the soil is not frozen. In Ontario, nematode soil population levels are generally at their highest in May–June and again in September–October.

How to Sample Soil

Samples should be taken with a soil sampling tube, trowel or narrow-bladed shovel. Soil should be sampled to a depth of 20–25 cm (8–10 in). If the soil is bare, the top 2 cm (1 in.) should be removed prior to sampling. A sample should consist of 10 or more subsamples combined. Mix well. Then take a sample of $^1/_2$–1 L (1 pint–1 quart) from this. No one sample should represent more than 2.5 ha (6.25 ac.) Subsamples should be mixed in a clean pail or plastic bag.

Sampling Pattern

If living crop plants are present in the sample area, samples should be taken within the row and from the area of the feeder root zone (with trees this is the drip line).

Number of Subsamples

Based on the total area sampled

500 m^2 (5,400 ft^2)	10 subsamples
500 m^2–0.5 ha (5,400 ft^2–1.25 ac.)	25 subsamples
0.5 ha–2.5 ha (1.25–6.25 ac.)	50 subsamples

Roots

From small plants, sample entire root system plus adhering soil. For large plants, 10–20 g ($^1/_2$–1 oz) fresh weight should be dug from the feeder root zone and submitted.

Problem Areas

Soil and root samples should be taken from the margins of the problem area where the plants are still living. If possible samples should also be taken from healthy areas in the same field. If possible, both soil and root samples should be taken from problem and healthy areas in the same field.

Sample Handling

Soil Samples

Place in plastic bags as soon as possible after collecting.

Root Samples

Place in plastic bags and cover with moist soil from the sample area.

Storage

Samples should be stored between 5°C and 10°C (40°F–50°F) and should not be exposed to direct sunlight or extreme heat or cold (freezing). Only living nematodes can be counted. Accurate counts are dependent on proper handling of samples.

Submitting Plant for Disease Diagnosis or Identification

Sample Submission Forms

Forms can be obtained from your local OMAFRA office. Carefully fill in all of the categories on the form. In the space provided, draw the most obvious symptom and the pattern of the disease in the field. It is important to include the cropping history of the area for the past 3 years and this year's pesticide use records.

Choose a complete, representative sample showing early symptoms. Submit as much of the plant as is practical, including the root system, or several plants showing a range of symptoms. For turfgrass, submit a 10–15 cm^2 piece of turf, including thatch and at least 5 cm of soil. The sample should be taken from the outside edge of a ring or patch and include healthy and unhealthy turf and the interface between. If symptoms are general, collect the sample from an area where they are of intermediate severity. Completely dead material is usually inadequate for diagnosis. Plant specimens submitted for identification should at least include a 20–25 cm sample of the top portion of the stem with lateral buds, leaves, flowers or fruits in identifiable condition. Wrap plants in newspaper and put in a plastic bag. Tie the root system off in a separate plastic bag to avoid drying out and soil contaminating the leaves. Do NOT add moisture, as this encourages decay in transit. Cushion specimens and pack in a sturdy box to avoid damage during shipping. Avoid leaving specimens to bake or freeze in a vehicle or in a location where they could deteriorate.

Delivery

Delivery to the Pest Diagnostic Clinic should be made as soon as possible by first class mail or by courier at the beginning of the week.

Submitting Insect Specimens for Identification

Collecting Samples

Dead, hard bodied insects and spiders should be placed in vials or boxes and cushioned with tissues or cotton. Soft bodied insects and caterpillars should be placed in vials containing alcohol. Do not use water as this will result in rot. Do not tape insect to paper or send them loose in an envelope.

Live insects should be placed in a container with enough plant "food" to support them during transit. Be sure to write "live" on the outside of the container.

APPENDIX C.
Phytosanitary Certificates

Phytosanitary certificates may be required by importing countries. A phytosanitary certificate is a certificate indicating that a shipment is free from recognized or quarantinable pests. Countries importing ginseng seed may require a phytosanitary certificate. The importing country will list the pests or conditions associated with certification. If you are shipping ginseng seed or living roots out of Canada it is best to check with the importing country to determine what rules, if any, may affect your shipment. Knowing the rules in advance will avoid situations where your perishable crop may be held up before entry

Phytosanitary certificates can be obtained through the Canadian Food Inspection Agency (CFIA) at one of the regional offices listed in Appendix IV.

APPENDIX D. Other Contacts

University of Guelph

Main Campus, Guelph, N1G 2W1
(519) 824-4120
www.uoguelph.ca

Alfred College, Alfred, K0B 1A0
(613) 679-2218
www.alfredc.uoguelph.ca/

Kemptville College, Kemptville, K0G 1J0
(613) 258-8336
www.kemptvillec.uoguelph.ca

Ridgetown College, Ridgetown, N0P 2C0
(519) 674-1500
www.ridgetownc.on.ca

Department of Plant Agriculture

www.plant.uoguelph.ca

Department of Plant Agriculture, Kettleby
1125 Woodchopper's Lane, R.R. # 1
Kettleby, L0G 1J0
(905) 775-3783

Department of Plant Agriculture, Simcoe
Box 587 Blue Line Road
Simcoe, N3Y 4N5
(519) 426-7127

Department of Plant Agriculture, Vineland
Box 7000, 4890 Victoria Avenue North
Vineland Station, L0R 2E0
(905) 562-4141

Lab Services Division

www.uoguelph.ca/labserv/

Pesticide and Trace Contaminants
P.O.Box 3650, 95 Stone Road West
Guelph, N1H 8J7
(519) 767-6200

Pest Diagnostic Clinic
(519) 767-6256

Agriculture and Agri-food Canada

Research Centres

Eastern Cereals and Oilseeds Research Centre
960 Carling Avenue
Ottawa, K1A 0C6
(613) 759-1952
http://res2agr.ca/ecorc/welcome.htm

Greenhouse and Processing Crops Research Centre
Harrow N0R 1G0
(519) 738-2251
http://res2.agr.ca/harrow/

Southern Crop Protection and Food Research Centre
1391 Sandford Street
London N5V 4T3
(519) 457-1470

Vineland Research Farm
4902 Victoria Avenue North
Vineland L0R 2E0
(905) 562-4113

Delhi Research Farm
Box 186 Schafer Road
Delhi N4B 2W9
(519) 582-1950
http://res2.agr.ca/london/pmrc/pmrchome.html

Canadian Food Inspection Agency

www.cifa-acia.agr.ca

Regional Offices (Plant Protection)

Belleville
345 College Street East
Belleville, K8N 5S7
(613) 969-3333

Hamilton
709 Main Street West, Suite 101
Hamilton, L8S 1A2
(905) 572-4152

London
457 Richmond Street, Suite 404
London, N6A 3E3
(519) 645-4021

Niagara Falls
Street address: 14154 Niagara River Parkway, Unit # 5
Mailing address: R.R #1, P.O. Box #7
Niagara on the Lake, L0S 1J0
(905) 262-5331

Brantford
Federal Building, Dalhousie & Queen St., P.O. Box 637
Brantford, N3T 5P9
(519) 751-8157

Ottawa District
3 Observatory Crescent
Building #3 Central, Experimental Farm
Ottawa, K1A 0C9
(613) 759-1571

Toronto
401 Champagne Drive, Unit 1
Downsview, M3J 2C6
(416) 954-1714

Windsor
441 University Avenue West, Suite 208
Windsor N9A 5P9
(519) 252-7095

APPENDIX E.
Accredited Soil Testing Labs in Ontario

The following labs are accredited to perform soil tests for pH, buffer pH, P, K, Mg and Nitrate-N on Ontario soils. There is no official accreditation in Ontario for tissue analysis, but all the accredited soil testing labs are monitored for proficiency on tissue analyses.

Laboratory Name	Address	Telephone/Fax/Email	Contact
A & L Canada Laboratories East. Inc. Web site: www.al-labs-can.com	2136 Jetstream Road LONDON, Ontario N5V 3P5	Tel: (519) 457-2575 Fax: (519) 457-2664 E-mail: aginfo@al-labs-can.com	Mr. Greg Patterson Mr. Ian McLachlin
Accutest Laboratories Web site: www.accutestlabs.com	146 Colonnade Road Unit #8 NEPEAN, Ontario K2E 7Y1	Tel: (613) 727-5692 Fax: (613) 727-5222 E-mail: phaulena@accutestlabs.com	Mrs. Lorna Wilson Mr. Peter Haulena
Agri-Food Laboratories Web site: www.agtest.com	503 Imperial Road Unit #1 GUELPH, Ontario N1H 6T9	Tel: (519) 837-1600 1-800-265-7175 Fax: (519) 837-1242 E-mail: lab@agtest.com	Mr. Dale Cowan Ms. Nora Wilson
Soil and Nutrient Laboratory (Formerly Analytical Services, Land Resource Science)	University of Guelph P.O. Box 3650 95 Stone Road West GUELPH, Ontario N1H 2W1	Tel: (519) 767-6226 Fax: (519) 767-6240 E-mail: vkerslak@lsd.uoguelph.ca	Ms. Virginia Kerslake
Stratford Agri Analysis (A Daco Laboratories Ltd.)	1131 Erie Street Box 760 STRATFORD, Ontario N5A 6W1	Tel: (519) 273-4411 1-800-323-9089 Fax: (519) 273-4411 E-mail: saa@dacolabs.com	Mr. Dale Peters Mr. Gary Roberts Mr. Keith Lemp

APPENDIX F.
Ontario Ministry of the Environment Pesticide Control Offices

REGION	**PESTICIDES OFFICER**	
County	**Address**	**Telephone**
Central Region Toronto, Halton, Peel York, Durham	**Charles Zubovits** 5775 Yonge Street 8th Floor Toronto, Ontario M2M 4J1	Tel: (416) 326-3671 Toll Free: 1-800-810-8048 Fax: (416) 325-6347
West-Central Region Haldimand-Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant	**Paul McCubbin** Ontario Government Building 119 King Street West 12th Floor Hamilton, Ontario L8P 4Y7	Tel: (905) 521-7667 Fax: (905) 521-7820
Eastern Region Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry , Haliburton, Peterborough, Victoria, Northumberland, Renfrew, Ottawa-Carleton, Lanark, District of Nipissing (Twsps of Airy, Murchison, Dickens, Lyell and Sabine)	**Andrew Morley** **Laurel Grills** 133 Dalton Avenue P.O. Box 820 Kingston, Ontario K7L 4X6	Tel: (613) 549-4000 Toll Free: 1-800-267-0974 Fax: (613) 548-6908
Southwestern Region Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth, Simcoe	**Doug Morrow** **Wray Lampman** 695 Exeter Road 2nd Floor London, Ontario N6E 1L3	Tel: (519) 873-5041 (519) 873-5048 Fax: (519)873-5020
Northern Region Manitoulin, Nipissing, Parry Sound, Sudbury, Algoma East, Cochrane East, Muskoka	**John Negusanti** 199 Larch Street Suite 1101 Sudbury, Ontario P3E 5P9	Tel: (705) 564-3249 Fax: (705)564-4180
Kenora, Rainy River, Thunder Bay, Algoma West, Cochrane West, Timmins	**Don Mitchell** 435 James Street South Suite 331 Thunder Bay, Ontario P7E 6S7	Tel: (807) 475-1712 Fax: (807) 475-1745
Standards Development Branch	Pesticides Section 40 St. Clair Avenue West 7th Floor Toronto, Ontario M4V 1M2	Tel: (416) 327-5519 Fax: (416) 327-2936
Approvals Branch	Pesticides Licensing 2 St. Clair Avenue West 12A Floor Toronto, Ontario M4V 1L5	Tel: (416) 314-8001 Fax: (416) 314-8452

APPENDIX G. The Metric System

Metric Units

Linear Measures (length)

10 millimetres (mm) = 1 centimetre (cm)

100 centimetres (cm) = 1 metre (m)

1,000 metres = 1 kilometre (km)

Square Measures (area)

100 m X 100 m = 10,000 m^2 = 1 hectare (ha)

100 ha = 1 square kilometre (km^2)

Cubic Measures (volume)

Dry Measure

1,000 cubic millimetres (mm^3) = 1 cubic centimetre (cm^3)

1,000,000 cm^3 = 1 cubic metre (m^3)

Liquid Measure

1,000 millilitres (mL) = 1 litre (L)

100 L = 1 hectolitre (hL)

Weight-Volume Equivalents (for water)

(1.00 kg) 1,000 grams = 1 litre (1.00 L)

(0.50 kg) 500 g = 500 mL (0.50 L)

(0.10 kg) 100 g = 100 mL (0.10 L)

(0.01 kg) 10 g = 10 mL (0.01 L)

(0.001 kg) 1 g = 1 mL (0.001 L)

Weight Measures

1,000 milligrams (mg) = 1 gram (g)

1,000 g = 1 kilogram (kg)

1,000 kg = 1 tonne (t)

1 mg/kg = 1 part per million (ppm)

Dry–Liquid Equivalents

1 cm^3 = 1 mL

1 m^3 = 1000 L

Application Rate Conversions

Metric to Imperial (Approximate)

litres per hectare x 0.09 = gallons per acre

litres per hectare x 0.36 = quarts per acre

litres per hectare x 0.71 = pints per acre

millilitres per hectare x 0.015 = fluid ounces per acre

grams per hectare x 0.015 = ounces per acre

kilograms per hectare x 0.89 = pounds per acre

tonnes per hectare x 0.45 = tons per acre

Imperial to Metric (Approximate)

gallons per acre x 11.23 = litres per hectare (L/ha)

quarts per acre x 2.8 = litres per hectare (L/ha)

pints per acre x 1.4 = litres per hectare (L/ha)

fluid ounces per acre x 70 = millilitres per hectare (mL/ha)

tons per acre x 2.24 = tonnes per hectare (t/ha)

pounds per acre x 1.12 = kilograms per hectare (kg/ha)

ounces per acre x 70 = grams per hectare (g/ha)

Liquid Equivalents

Litres/Hectare		*Approximate Gallons/Acre*
50	=	5
100	=	10
150	=	15
200	=	20
250	=	25
300	=	30

Dry Weight Equivalents

Grams or Kilograms / Hectare		*Ounces or Pounds /Acre*
100 grams	=	1½ ounces
200 grams	=	3 ounces
300 grams	=	4¼ ounces
500 grams	=	7 ounces
700 grams	=	10 ounces
1.10 kilograms	=	1 pound
1.50 kilograms	=	1⅓ pounds
2.00 kilograms	=	1¾ pounds
2.50 kilograms	=	2¼ pounds
3.25 kilograms	=	3 pounds
4.00 kilograms	=	3½ pounds
5.00 kilograms	=	4½ pounds
6.00 kilograms	=	5¼ pounds
7.50 kilograms	=	6¾ pounds
9.00 kilograms	=	8 pounds
11.00 kilograms	=	10 pounds
13.00 kilograms	=	11½ pounds
15.0 kilograms	=	13½ pounds

Metric Conversions

5 mL = 1 tsp

15 mL = 1 tbsp

28.5 mL = 1 fl. oz

Conversion Tables — Metric to Imperial

Length		
1 millimetre (mm)	=	0.04 inch
1 centimetre (cm)	=	0.40 inch
1 metre (m)	=	39.40 inches
1 metre (m)	=	3.28 feet
1 metre (m)	=	1.09 yards
1 kilometre (km)	=	0.62 mile
Area		
1 square centimetre (cm^2)	=	0.16 square inch
1 square metre (m^2)	=	10.77 square feet
1 square metre (m^2)	=	1.20 square yards
1 square kilometre (km^2)	=	0.39 square mile
1 hectare (ha)	=	107,636 square feet
1 hectare (ha)	=	2.5 acres
Volume (dry)		
1 cubic centimetre (cm^3)	=	0.061 cubic inch
1 cubic metre (m^3)	=	1.31 cubic yards
1 cubic metre (m^3)	=	35.31 cubic feet
1,000 cubic metres (m^3)	=	0.81 acre-foot
1 hectolitre (hL)	=	2.8 bushels
Volume (liquid)		
1 millilitre (mL)	=	0.035 fluid ounce
1 litre (L)	=	1.76 pints
1 litre (L)	=	0.88 quart
1 litre (L)	=	0.22 gallon (Imp.)
1 litre (L)	=	0.26 gallon (U.S.)
Weight		
1 gram (g)	=	0.035 ounce
1 kilogram (kg)	=	2.21 pounds
1 tonne (t)	=	1.10 short tons
1 tonne (t)	=	2,205 pounds
Pressure		
1 kilopascal (kPa)	=	0.15 pounds/in^2
Speed		
1 metre per second	=	3.28 feet per second
1 metre per second	=	2.24 miles per hour
1 kilometre per hour	=	0.62 mile per hour
Temperature		
°F	=	(°C X $^9/_5$) + 32

Conversion Tables — Imperial to Metric

Length		
1 inch	=	2.54 cm
1 foot	=	0.30 m
1 yard	=	0.91 m
1 mile	=	1.61 km
Area		
1 square foot	=	0.09 m^2
1 square yard	=	0.84 m^2
1 acre	=	0.40 ha
Volume (dry)		
1 cubic yard	=	0.76 m^3
1 bushel	=	36.37 L
Volume (liquid)		
1 fluid ounce (Imp.)	=	28.41 mL
1 pint (Imp.)	=	0.57 L
1 gallon (Imp.)	=	4.55 L
1 gallon (U.S.)	=	3.79 L
Weight		
1 ounce	=	28.35 g
1 pound	=	453.6 g
1 ton	=	0.91 tonne
Pressure		
1 pound per square inch	=	6.90 kPa
Temperature		
°C	=	(°F – 32) x $^5/_9$

Abbreviations

% = per cent (by weight)
ai = active ingredient
AP = agricultural powder
cm = centimetre
cm^2 = square centimetre
DG = dispersible granular
DP = dispersible powder
E = emulsifiable
e.g. = for example
EC = emulsifiable concentrate
F = flowable
g = gram
Gr = granules, granular
ha = hectare
kg = kilogram
km/h = kilometres per hour
kPa = kilopascal
L = litre
m = metre
m/s = metres per second
m^2 = square metre
mL = millilitre
mm = millimetre
SC = sprayable concentrate
SP = soluble powder
t = tonne
W = wettable (powder)
WDG = water dispersible granular
WP = wettable powder
km/h = kilometres per hour

9. Colour Plates

PLATE 1. Grading for water removal. Note the perimeter ditch that collects and directs water flow away from the garden trenches.

PLATE 2. Waterway hazard. Note the missing plants in the path of natural water flow. *Phytophthora* will move from this area on machinery throughout the garden.

PLATE 3. Standing water. Note the water that has pooled in the trenches. *Phytophthora* will develop rapidly in adjacent beds.

PLATE 4. Forming the beds. In some gardens, beds are formed after the posts are set. In others, the posts are set after bed formation.

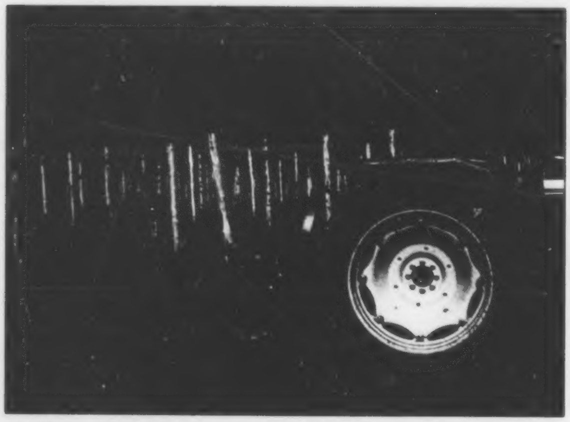


PLATE 5. Bed-forming equipment. Some growers form the beds and then seed. Others do these operations simultaneously.

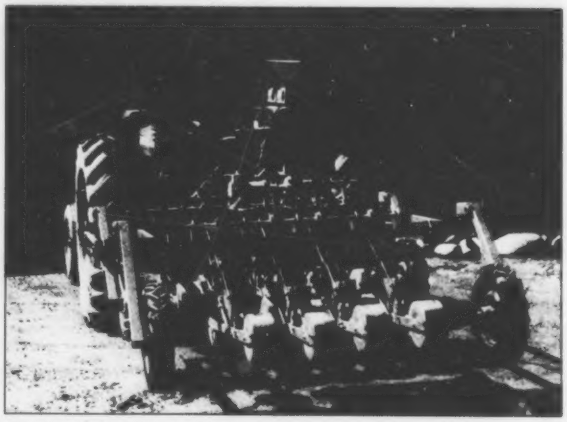


PLATE 6. Seeding. There are a variety of precision seeders that can be used in ginseng gardens. This seeder is set to sow 12 rows of seed across the bed.

PLATE 7. Applying straw. It is essential to apply straw mulch as soon after seeding as possible. Equipment can be adapted for use with small bales, large round bales and large square bales.

PLATE 8. Low wood shade.

PLATE 9. Low cloth shade.

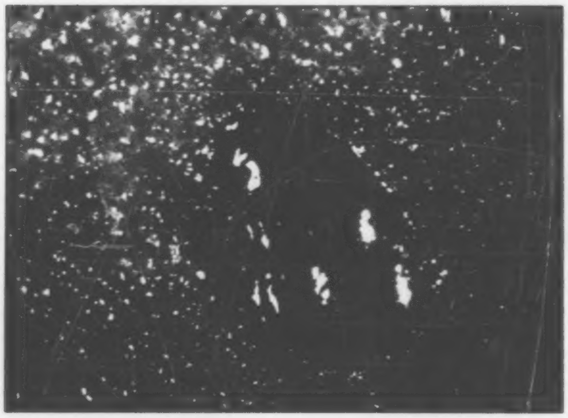


PLATE 10. Ginseng embryo. At the time of seed harvest, the ginseng embryo is about .5 mm in length. It will increase in size tenfold before it germinates.

PLATE 11. Seed infected with *Rhizoctonia* is usually discoloured inside. The rusty area of decay can vary in size. Unless decay is advanced, the seed will sink during the float test.

PLATE 12. *Pythium* infection usually results in total decay of the seed, leaving a "cheesy" interior. Such a seed could be culled out by floating.

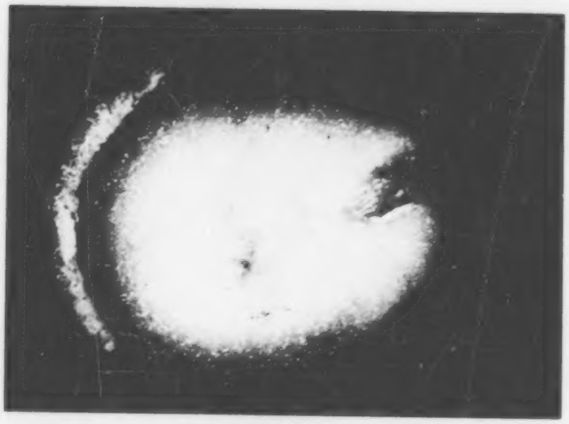


PLATE 13. *Fusarium* and *Cylindrocarpon* also discolour the interior of the seed. Even very small areas of seed decay can lead to seedling death.

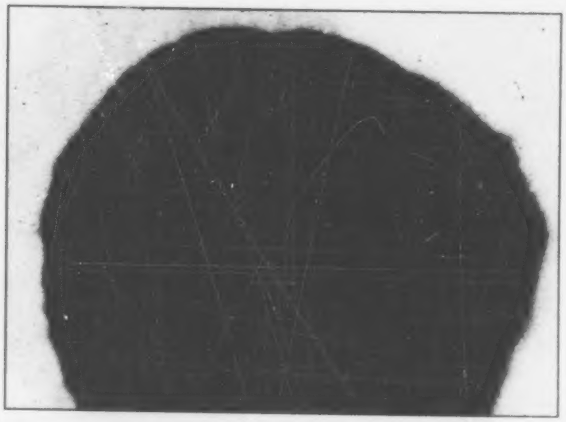


PLATE 14. *Cylindrocarpon* sporodochia. The cushion-like bodies that contain many conidia can be found on the exterior of ginseng seeds when *Cylindrocarpon* is present inside the seed. *Fusarium* also produces sporodochia.

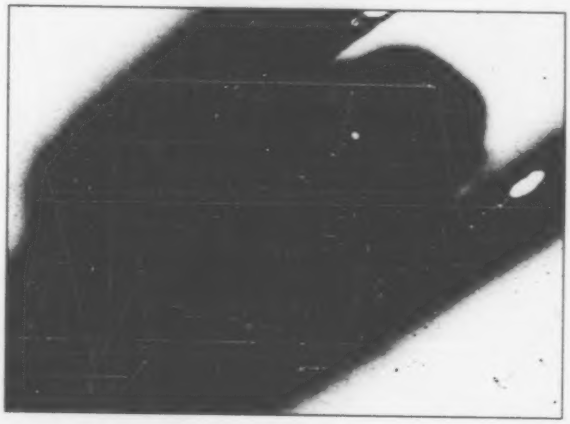


PLATE 15. Bacterial seed decay. Note the bacterial ooze extruding from the micropore.

PLATE 16. Harvesting berries. Ginseng berries are harvested by hand and collected in baskets. Some growers place them in burlap bags to let the pulp rot. Some use a mechanical depulper.

PLATE 17. Depulping berries. A mechanical depulper scrapes the berry pulp off the seeds through tumbling rotary action.

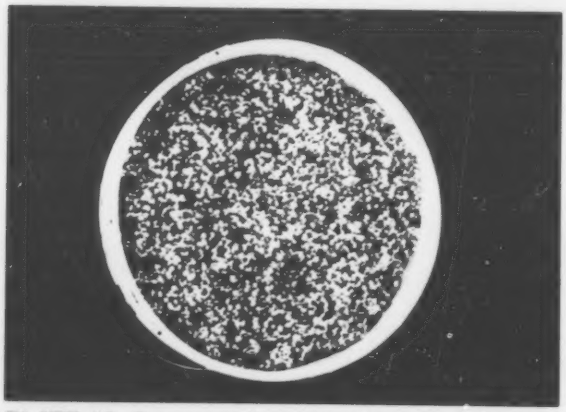


PLATE 18. Green seed must not be allowed to dry out.

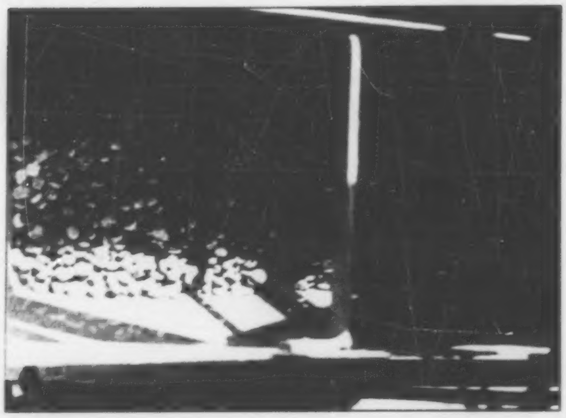


PLATE 19. The seedbox. An appropriate seedbox will be plastic and will have enough holes for good drainage. Some boxes are constructed with a screen as a bottom.

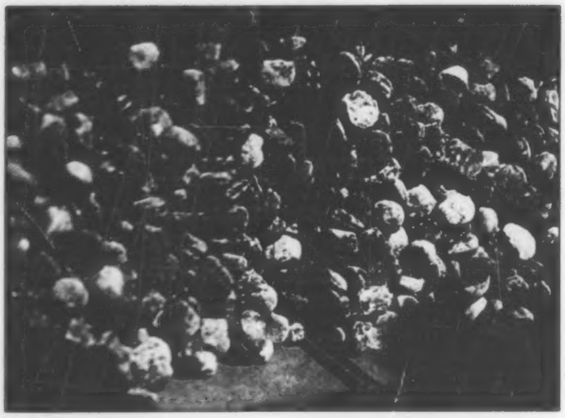


PLATE 20. Stratified seed. Stratified ginseng seed is still very hard. The embryo is only half developed.

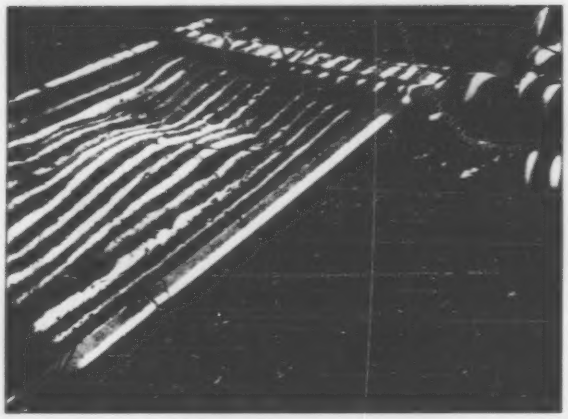


PLATE 21. Checking seed. The seedbox should be checked throughout the summer to assess seed health.

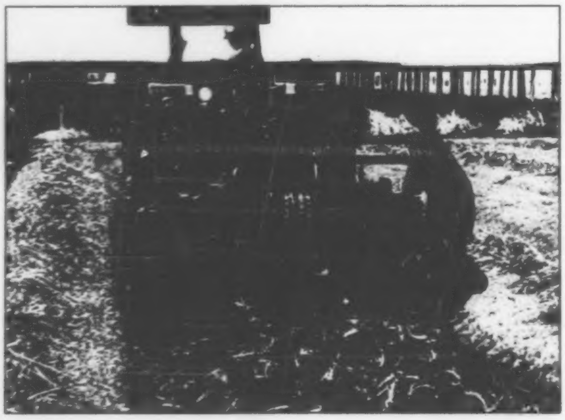


PLATE 22. Root harvest. A modified potato digger is commonly used to dig ginseng root. Some growers use machinery that digs and picks up the root to reduce labour costs.

PLATE 23. Conditioning root. Freshly dug root is placed in containers to be refrigerated for 2–4 weeks prior to drying.

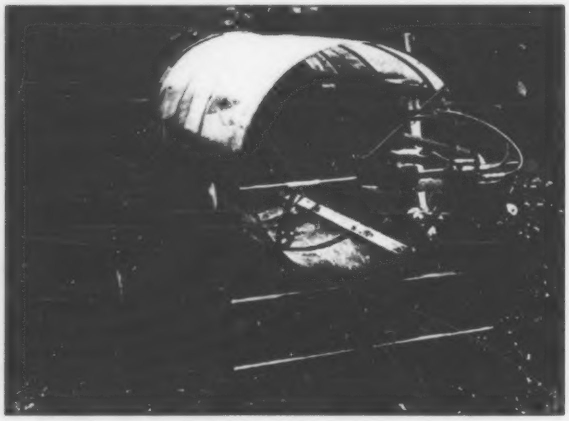


PLATE 24. Washing root. After conditioning, the root is washed in a tumble washer.

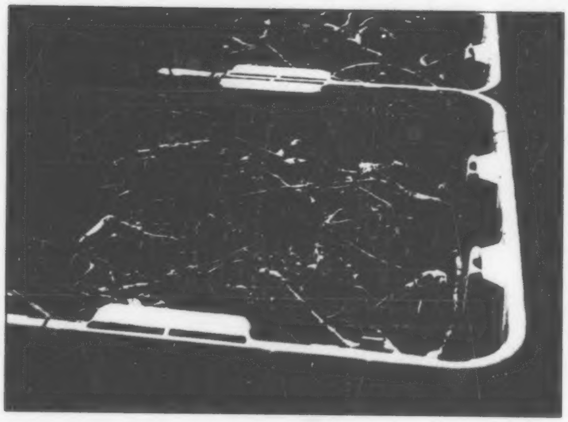


PLATE 25. Unwashed root. Unwashed root is usually too dirty to put directly into the dryer.

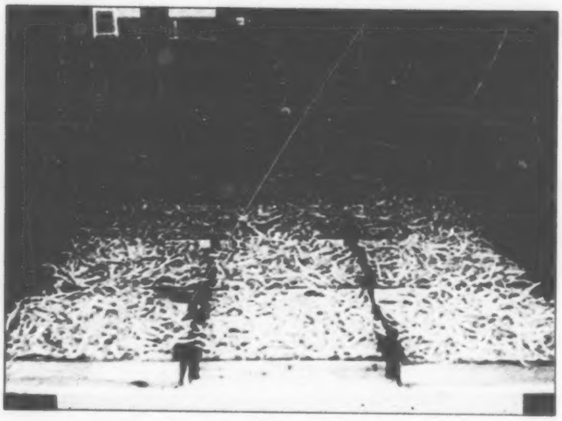


PLATE 26. Washed root. Washing the root removes loose soil. Roots can be overwashed, in which case their value will be reduced.

PLATE 27. Drying trays. Drying trays should not be so deep that the roots remain hot and humid for a long period of time at the onset of drying. Various sizes are usually mixed together.

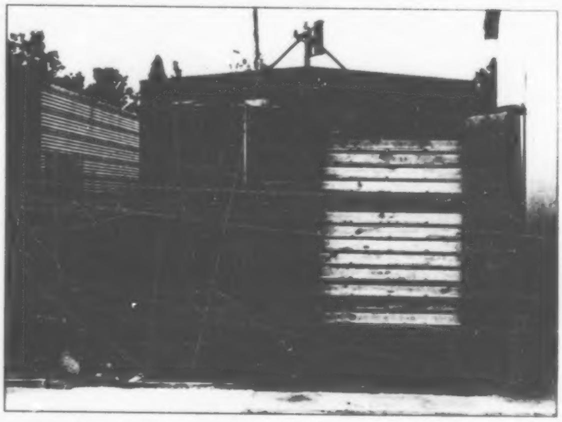


PLATE 28. Drying kiln. Trays are loaded in a drying kiln. Bulk tobacco kilns can be modified for use with ginseng.

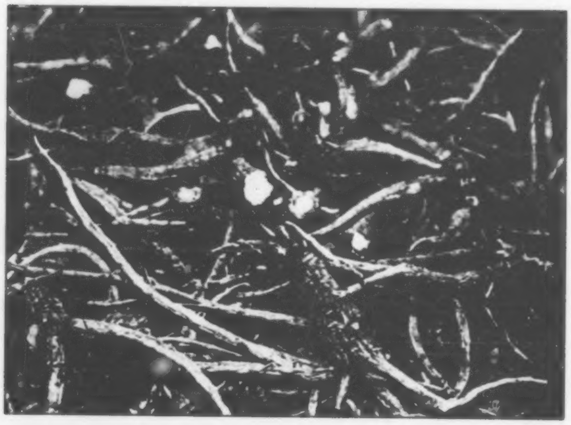


PLATE 29. Dried root has a greyish-brown exterior and a creamy white interior.

PLATE 30. Ideally, the interior colour of the roots is a creamy white.

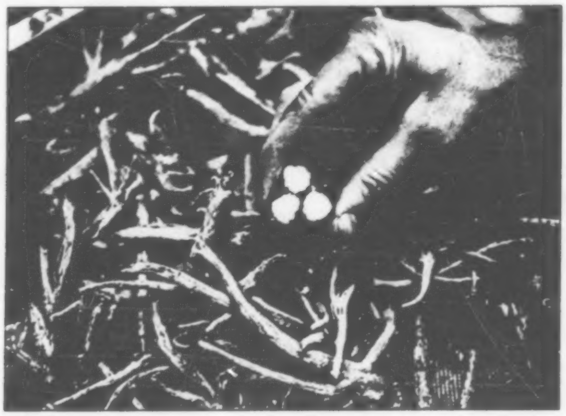


PLATE 31. Roots dried at too high a temperature will be dark inside and have dark rings that lower their value.

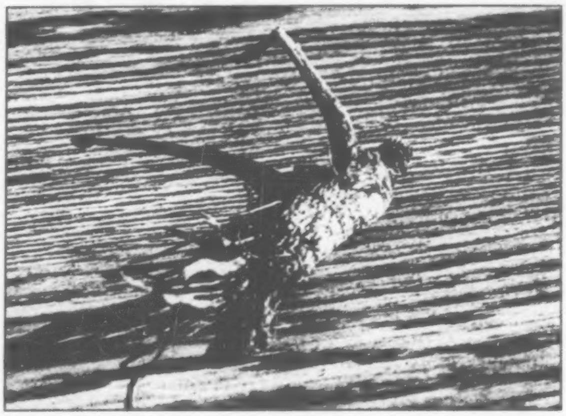


PLATE 32. Red root. Sometimes dried root shows a series of red streaks lengthwise just under the root surface.

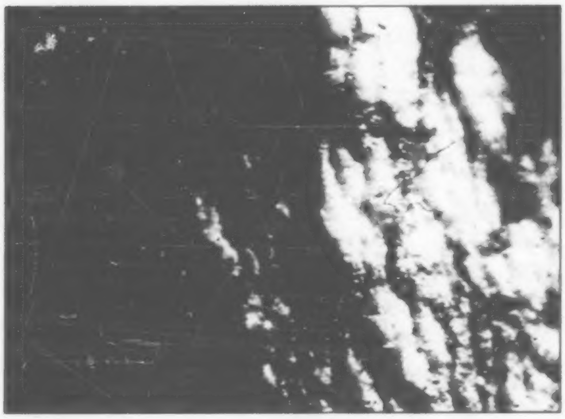


PLATE 33. A close-up look at these streaks indicates the ducts where the phenolic compounds have developed.

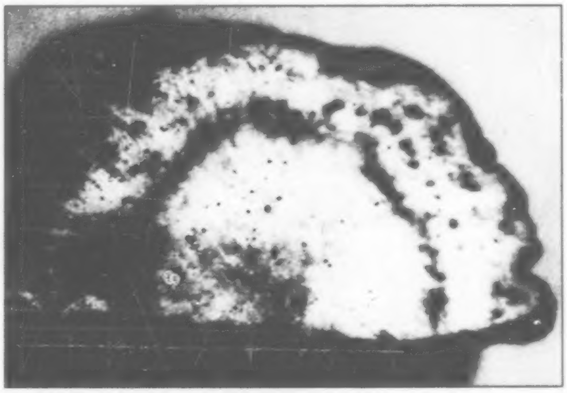


PLATE 34. A cross-section of these roots shows the distinct ducts as a series of red dots.

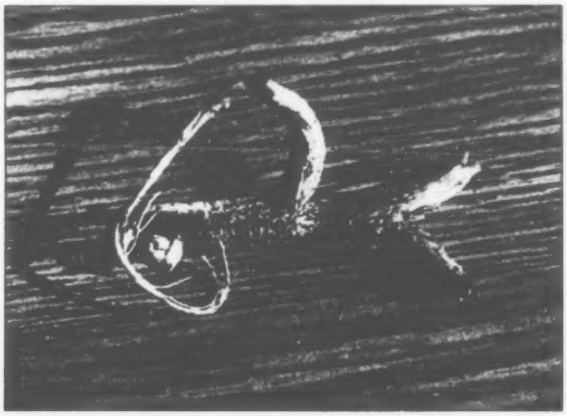


PLATE 35. *Rhizopus* infection in the dryer results in the development of grey patches on the root.

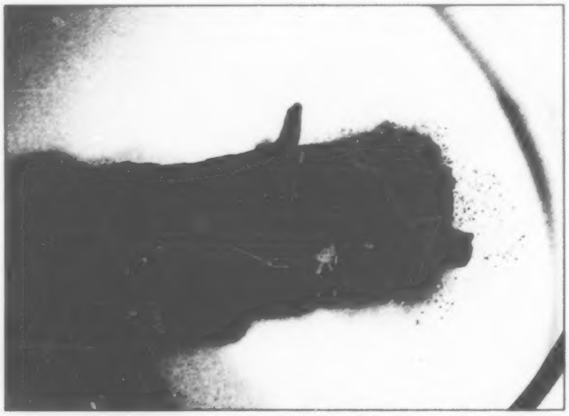


PLATE 36. *Rhizopus* is growing from roots that were infected in the kiln and subsequently moistened.

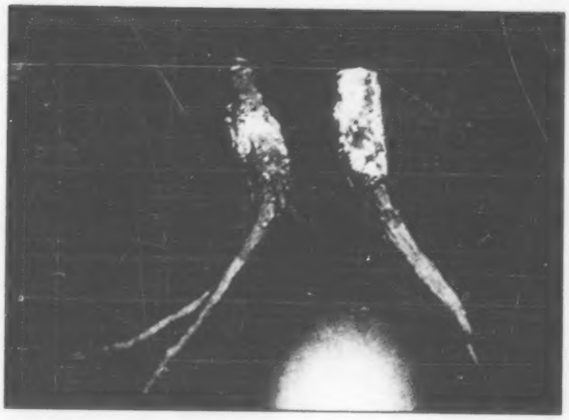


PLATE 37. *Geotrichum* rot has a distinctive dirty white fuzzy appearance and a sour odour.

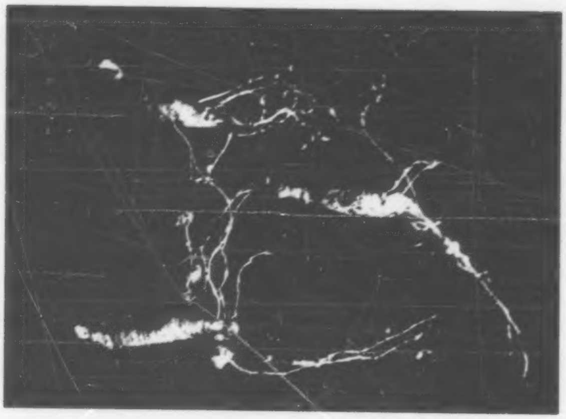


PLATE 38. Nematode galls. Damage from root-knot nematodes results in the formation of galls along the feeder roots.

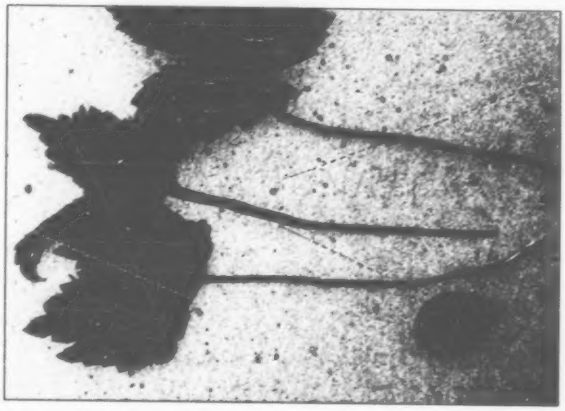


PLATE 39. Cutworm damage. Cutworms can cut off the stems of seedlings. Unless the root has sufficiently developed and set a bud for next year's new growth, the plant will not survive.

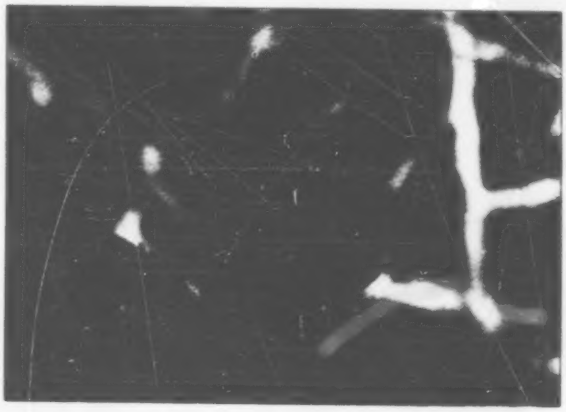


PLATE 40. A four-lined plant bug can be seen perched at the tip of a mint leaf adjacent to a seedling ginseng garden.

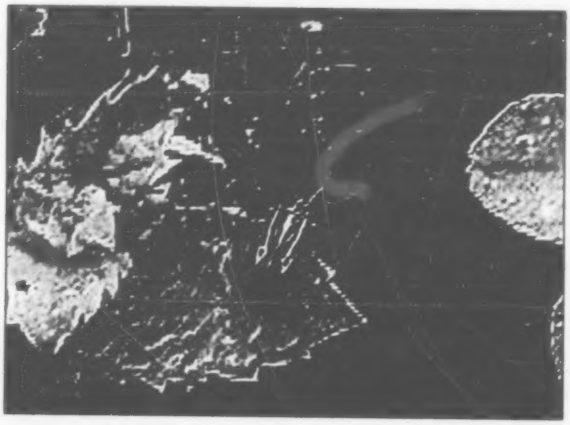


PLATE 41. Four-lined plant bug. The four-lined plant bug has distinctive markings consisting of four black stripes that extend the length of the wings. It is quick and shy.

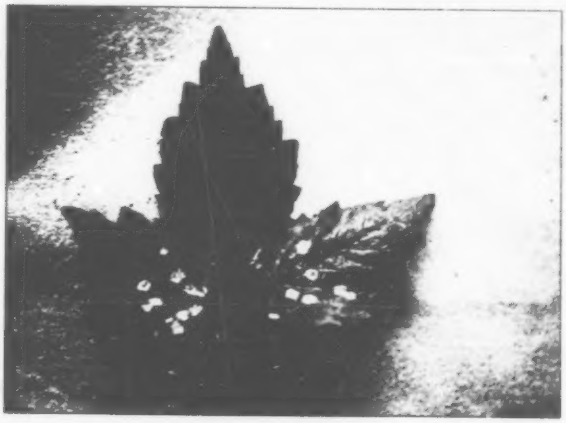


PLATE 42. Leaf damage from four-lined plant bug feeding consists of white spots due to the removal of leaf chlorophyll. This damage is enough to seriously injure ginseng seedlings.

PLATE 43. Leaf damage due to four-lined plant bug on older plants is seldom sufficient to cause economic loss.

PLATE 44. A mint plant at the end of a bay in seedling gardens protects seedling plants from damage from four-lined plant bug.

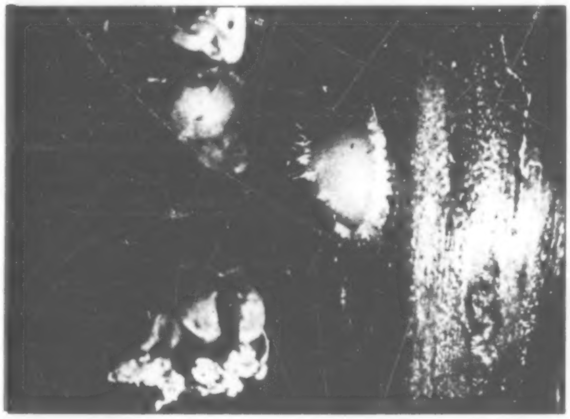


PLATE 45. The adult pit scale attaches to the stem and peduncles of ginseng plants. Note the depression in this peduncle where the scale attaches.

PLATE 46. The distortion caused by the toxic saliva of the pit scale results in twisted stems. Distorted plants can be well below the rest of the plant canopy.

PLATE 47. Leaf roller in ginseng. The larvae manipulate leaves so they can be easily wrapped together with silk strands. The larvae use these shelters as a base when they forage for food.

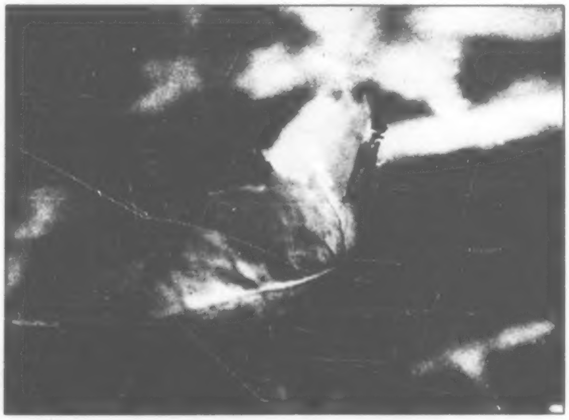


PLATE 48. Leaf roller larvae. The larvae grow to about 2.5 cm in length. No economic loss has been recorded from leaf roller damage in ginseng.

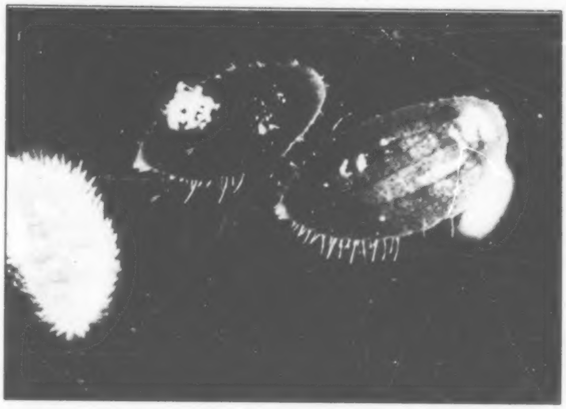


PLATE 49. *A. dubius* on ginseng. Note the scant waxy secretions on the surface of the mealybug.

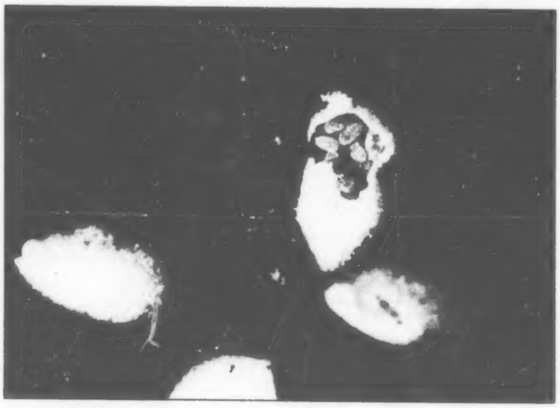


PLATE 50. Egg cases of *A. dubius*. Note the waxy secretion on the surface of the egg case and the salmon-coloured eggs inside.

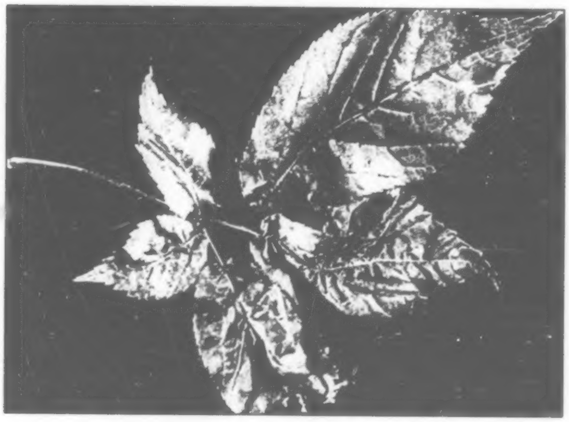


PLATE 51. *A. dubius* damage on ginseng due to toxins injected when feeding. Note that the mealybug prefers the main veins of the leaflets. This differs from the pit scale, which prefers the stems and peduncles.

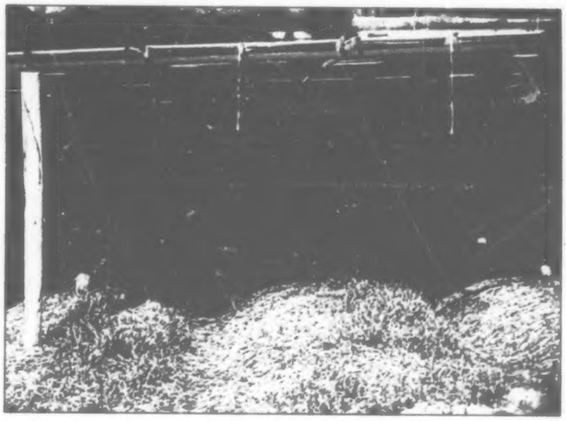


PLATE 52. Volunteer cereal in ginseng. Application of straw mulch usually means application of 2–3 bu/acre of cereal kernels. In the case of rye, these volunteer plants will survive most Ontario winters.

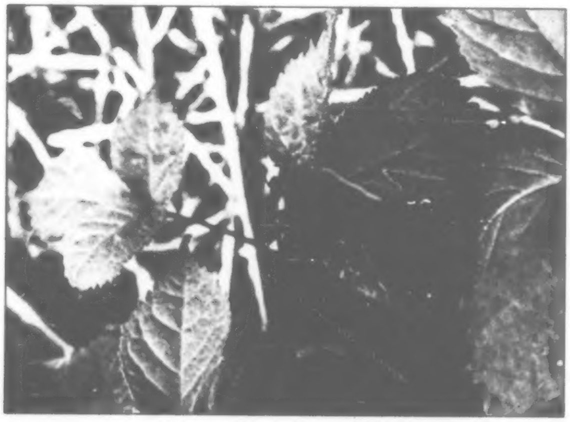


PLATE 53. Slug damage. Emerging plants attacked by slugs will grow around damaged areas, resulting in distorted leaves.

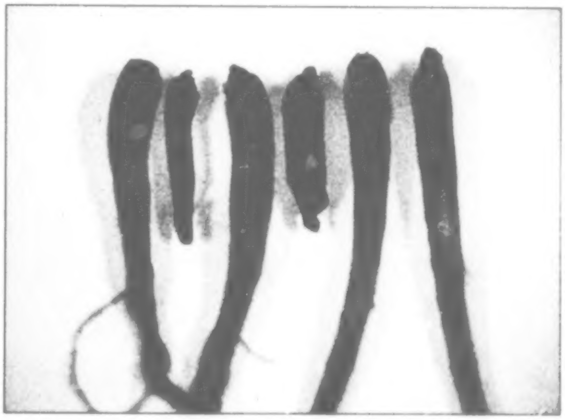


PLATE 54. Pythium root rot. *Pythium* has decayed the root tips. Note the absence of feeder roots. Sometimes *Pythium* damage results in the proliferation of feeder roots.

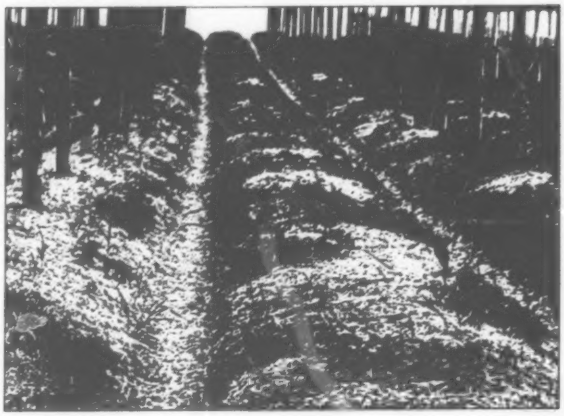


PLATE 55. *Rhizoctonia* in ginseng. A 2-year-old garden showing typical "circles" of plants lost to root decay during the winter months.

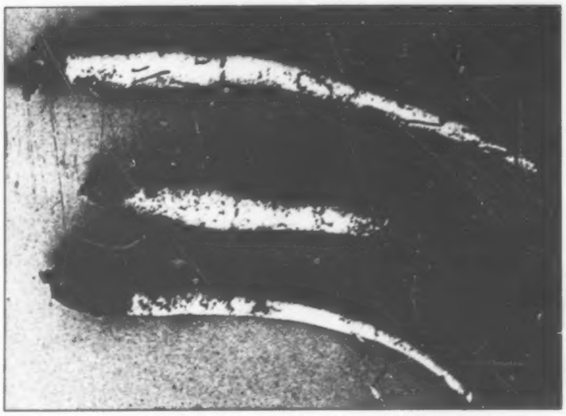


PLATE 56. Typical sites of infection. From the top: rhizoctonia crown rot, bud rot, and stem canker of 2-year-old plants.

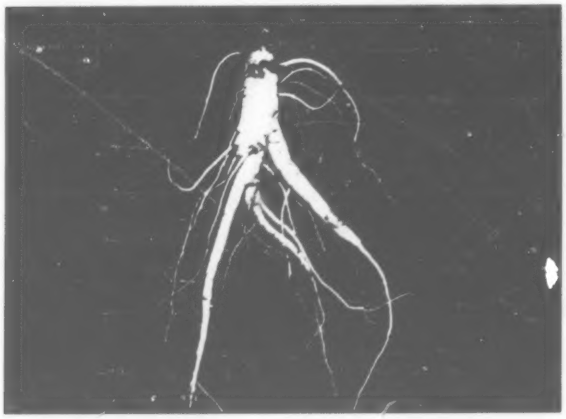


PLATE 57. Typical "rusty" lesion on older roots caused by *Rhizoctonia*. Rhizoctonia rot on older roots is less severe but can cause enough damage to make the root unmarketable.

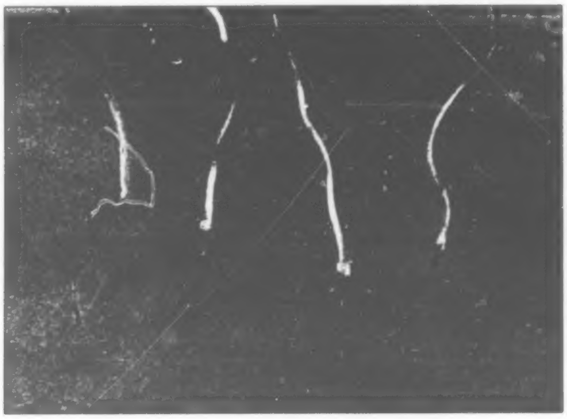


PLATE 58. Young seedlings attacked by *Rhizoctonia* show typical rusty lesions on the roots. These plants will not survive.

PLATE 59. A 2-year-old root that failed to emerge in the spring shows *Rhizoctonia* decay on the crown and bud.

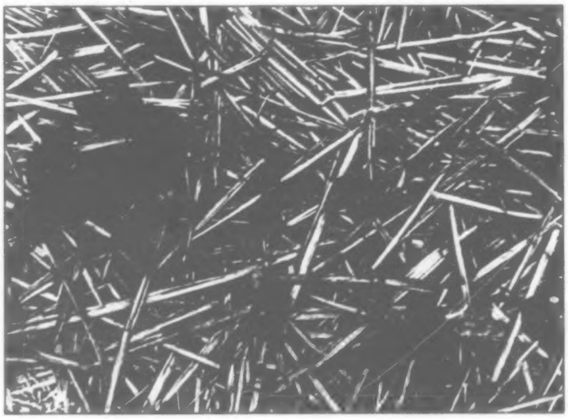


PLATE 60. Seedlings attacked after they emerge will topple and die. The symptom is called damping-off and can also be caused by *Pythium* and *Cylindrocarpon*.

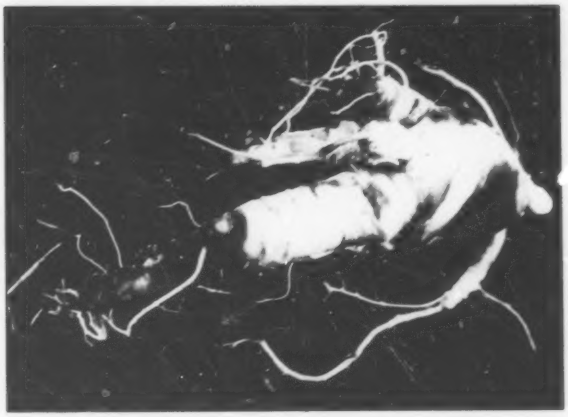


PLATE 61. Phytophthora root rot. Note the pinkish-brown colour of the decayed areas of the root.

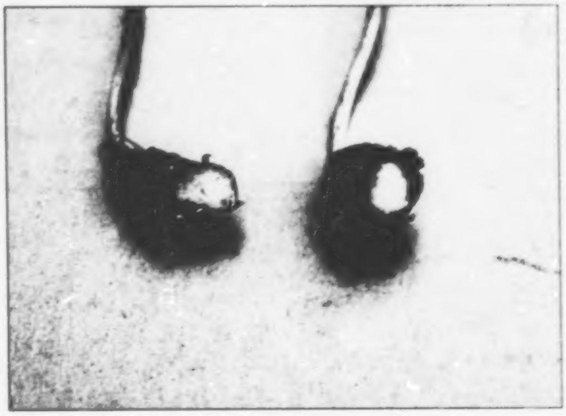


PLATE 62. A comparison of root decay caused by *Phytophthora*, left, and *Cylindrocarpon*, right. Note the "cheesy" interior of the root infected with *Phytophthora*.

PLATE 63. Phytophthora root rot. Note the collapse of only one of the leaves on this plant. This is typical of phytophthora root rot in ginseng.

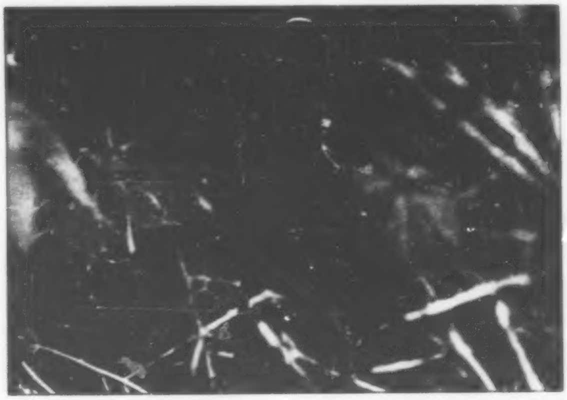


PLATE 64. As *Phytophthora* root decay advances, the entire top of the plant wilts and topples over.

PLATE 65. Foliar *Phytophthora*. When the fungus invades the leaves, it causes a rapidly expanding water-soaked lesion. Under warm, humid conditions, the fungus develops quickly.

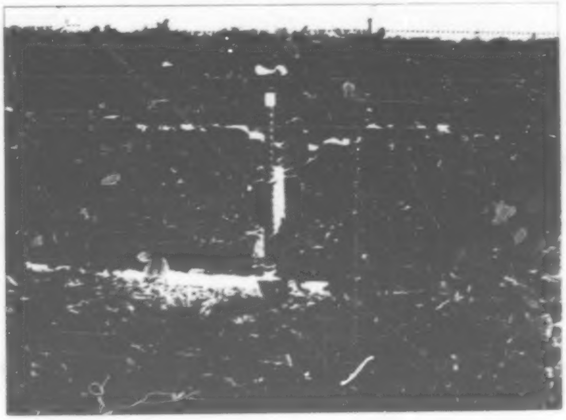


PLATE 66. Phytophthora root rot can develop under sprinklers that leak. Note the area of missing plants beside this sprinkler.

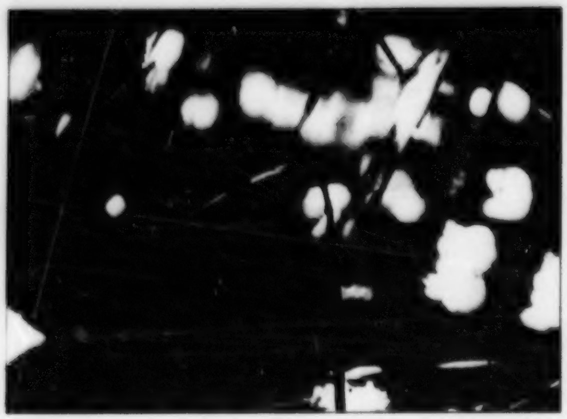


PLATE 67. *Alternaria* stem lesion. Note the sharp angle where the brittle *Alternaria* lesion has bent over.

PLATE 68. *Alternaria* lesions. Note the chlorotic "halo" surrounding the tan lesions on the leaves. *Alternaria* lesions are roughly circular.

PLATE 69. This garden was defoliated in less than 7 days from the appearance of the first leaf infection. If fungicides are applied after the fungus becomes established, control is difficult.

PLATE 70. Alternaria head blight. Note the darkened, shrivelled berries in the seed head on the left and the "blasting" of the two seedheads on the right.

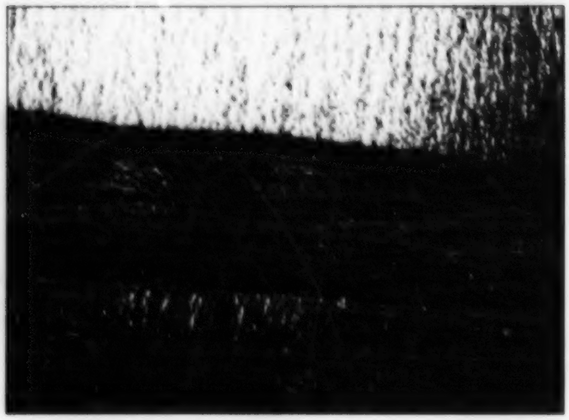


PLATE 71. *Botrytis* sclerotia. Note the black sclerotial bodies on the old stem.

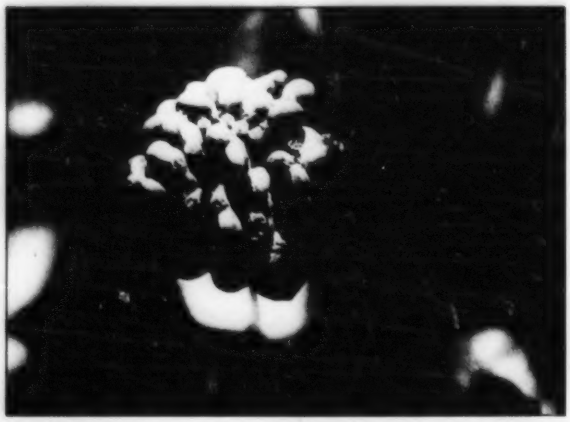


PLATE 72. Botrytis head blight. Note the purple colour of the infected berries. Berries are less shriveled than when infected with *Alternaria*.

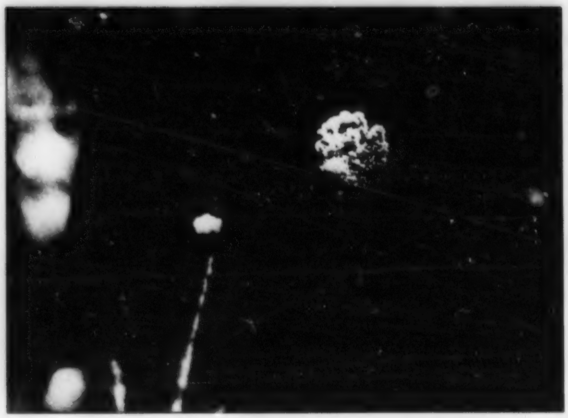


PLATE 73. Botrytis head blight. Note the mass of "fuzzy" conidia on the seed head.

PLATE 74. Plant-to-plant spread. Note the collapsed, decayed leaves on top of the healthy leaves. The fungus uses the decaying tissue as a nutritional "boost" to infect healthy tissue.

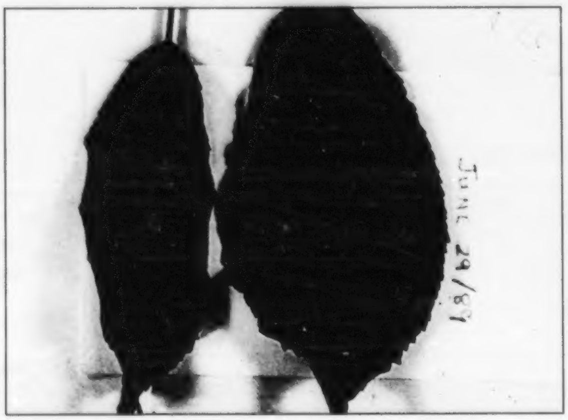


PLATE 75. Botrytis leaf blight. Note the similarity to phytophthora leaf blight. Leaves infected with *Botrytis* quickly collapse and become tan-coloured.

PLATE 76. Botrytis leaf blight is more prevalent at the leaf tips, and affected leaves appear wilted.

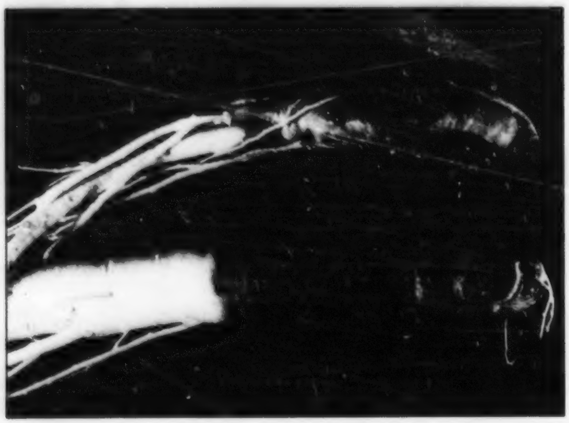


PLATE 77. *Botrytis* root infections can be covered with the same black sclerotia as the old stems. Root decay is rapid.

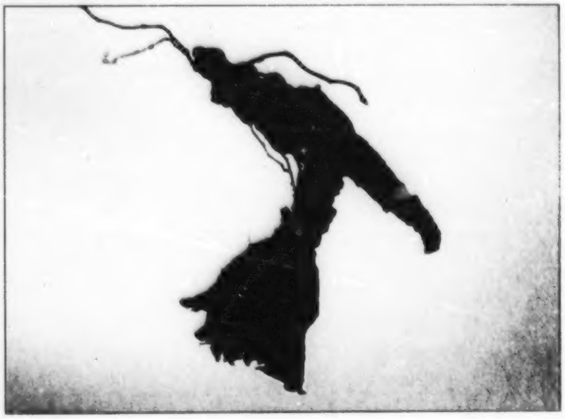


PLATE 78. Cylindrocarpon root rot. Note the total decay of the ginseng root. Roots usually decay from the bottom up.

PLATE 79. Seedling roots infected with *Cylindrocarpon* may be left alive but with stubby, distorted roots.

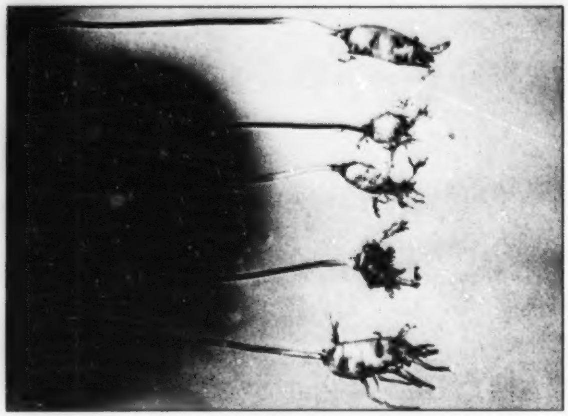


PLATE 80. Stubby two-year-old roots with *Cylindrocarpon* infection. Note the rusty lesions on both the remainder of the main root and the feeder roots.

PLATE 81. Leaves that discolour well before the garden senesces are usually infected with root decay.

PLATE 82. Where *Cylindrocarpon* infection is advanced, plants begin to wilt and dry up. This symptom does not occur until the root is almost entirely decayed.

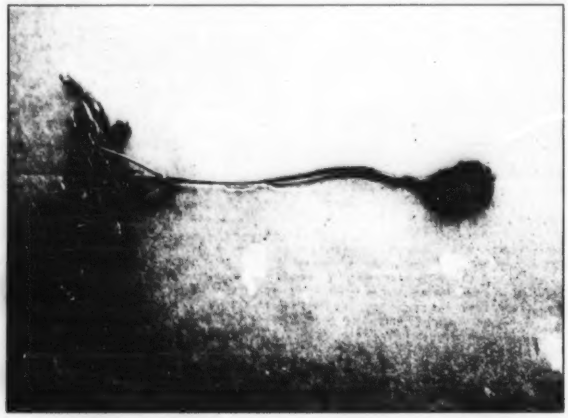


PLATE 83. Disappearing root rot. Note the blackened stub of the root infected with *Cylindrocarpon*. Decay is often this advanced before above-ground symptoms are apparent.

PLATE 84. *Cylindrocarpon* infections frequently begin at the tip of the tap root.

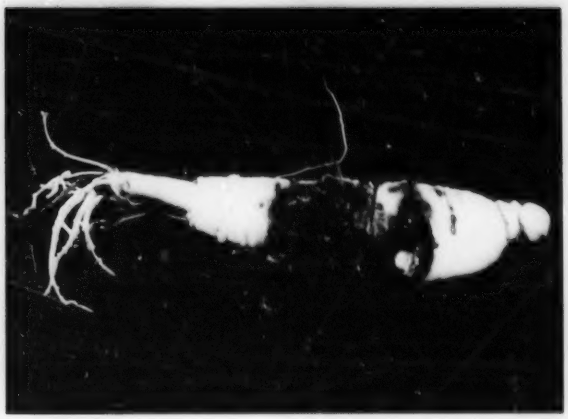


PLATE 85. *Cylindrocarpon* infection can also occur mid-root. Note the absence of feeder roots.

PLATE 86. The symptoms of rusty root, *Rhizoctonia* and *Cylindrocarpon* can easily be confused. This root had no pathogens associated with the decayed area and probably succumbed to rusty root.

PLATE 87. Rusty root. Note the scaly, rust-coloured lesion on this 4-year-old root.

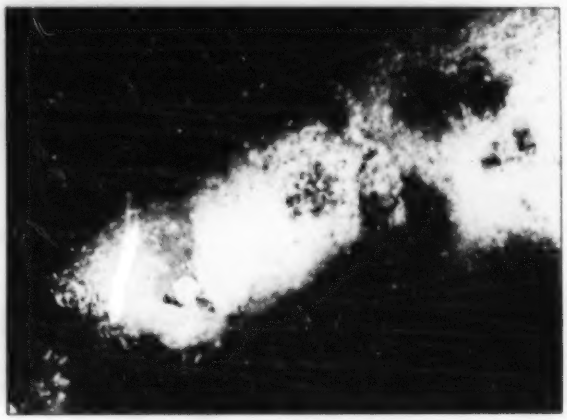


PLATE 88. This close-up shows superficial rust lesions along the crown of the root. Under adverse environmental conditions, the root decay will progress.

PLATE 89. *Rhizoctonia* lesions can occur on older root. When they do, they can be mistaken for either rusty root or *Cylindrocarpon*.

PLATE 90. This root has rust on the crown area. Crown rust can be associated with low temperatures when the straw is too thin during the winter.

PLATE 91. Papery leaf spot. Note the light-coloured, papery lesions on the leaves. The only other disease that causes this symptom is verticillium wilt, which has not yet been recorded in Ontario ginseng.

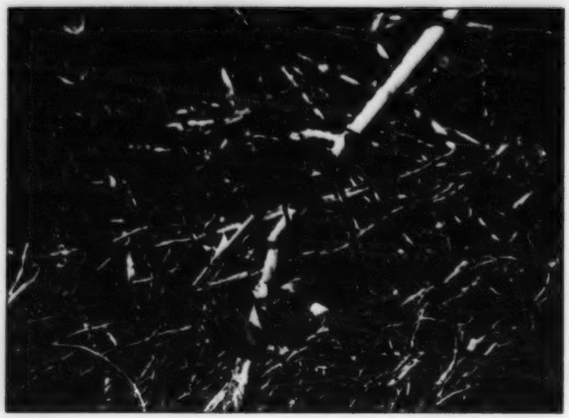


PLATE 92. Ozone and sulfur dioxide toxicity symptoms on ginseng. Note the white areas on the leaves.

PLATE 93. Boron toxicity in ginseng. Note the yellowish-white leaf borders. This area will eventually turn brown.

PLATE 94. Herbicide drift. Note the strap-like leaves on the emerged ginseng. Herbicide residues were found in the leaves and stems of affected plants.

PLATE 95. Herbicide leaf burn. The sprayer used to apply Bravo to this garden had been used to apply Roundup (glyphosate) to a neighbouring field.

PLATE 96. Fertilizer burn. Note the leaf toxicity due to excess zinc in the fertilizer-Dithane tank mix.

Emergency and First-Aid Procedures for Pesticide Poisoning

- Become familiar with the chemicals you are using. Keep a list of common names in case of accidents or emergencies. Common names are written on product labels and are cross-referenced in this publication. More extensive first-aid information is on product Material Safety Data Sheets (MSDS). These sheets are posted on company Web sites or are available from the farm supply centre where the chemical was purchased.
- If a pesticide comes in contact with the skin or is spilled on clothing, remove the clothing and wash the skin thoroughly with soap and warm water.
- If pesticide comes in contact with the eyes, rinse them continuously with clean water for 15 minutes. Repeat.
- If you suspect poisoning from exposure to a pesticide by swallowing, inhalation, or contact with skin or eyes, read the label on the pesticide container. Carry out the first-aid treatment suggested. Emergency phone numbers are listed on all product labels.
- **Immediately after first-aid treatment, wrap the patient in a coat or blanket and rush him/her to the nearest hospital. Take the list of chemical common names with you and identify the ones being used.**
- **If a person is unconscious, or lapses into unconsciousness, call an ambulance immediately.**
- **Emergency advice on pesticide poisoning is available from the Regional Poison Information Centres at:**

  Toronto 1-800-268-9017 Ottawa (bilingual) 1-800-267-1373
- **Those needing hearing assistance should call: 1-416-597-0215 (TTY)**
  Emergency telephone numbers are listed at the front of each
  Bell telephone directory.

  Fill in the following:

  My Local Poison Information Centre Telephone Number is:

  ______-________________________________

For information, or to obtain copies of this or any other ministry publication, please: call 1-888-4-OMAFRA (1-888-466-2372) from within Ontario, (519) 826-3700 from outside the province or OMAFRA's TTY line at (519) 826-7402 for the hearing impaired, email your request to *products@omafra.gov.on.ca*, or visit OMAFRA's web site at *www.gov.on.ca/omafra*.

A complete listing of all OMAFRA products and services, and order forms, are available on the web site. Orders can be faxed to (519) 826-3633 or mailed to Government Information Centre, OMAFRA, 1 Stone Road West, Guelph, ON N1G 4Y2

Published by the Ministry of Agriculture, Food and Rural Affairs
© Queen's Printer for Ontario, 2001 Toronto, Canada
ISSN 1496-502X
RV 03-01-1.5M